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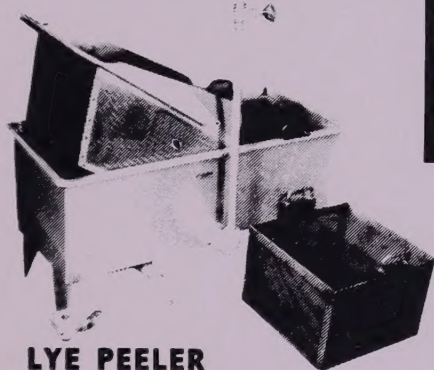
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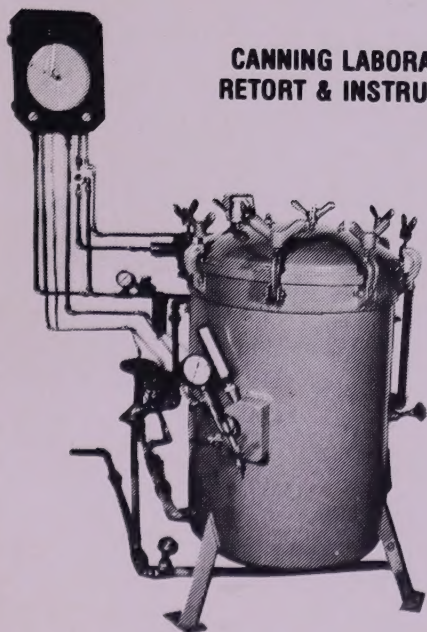
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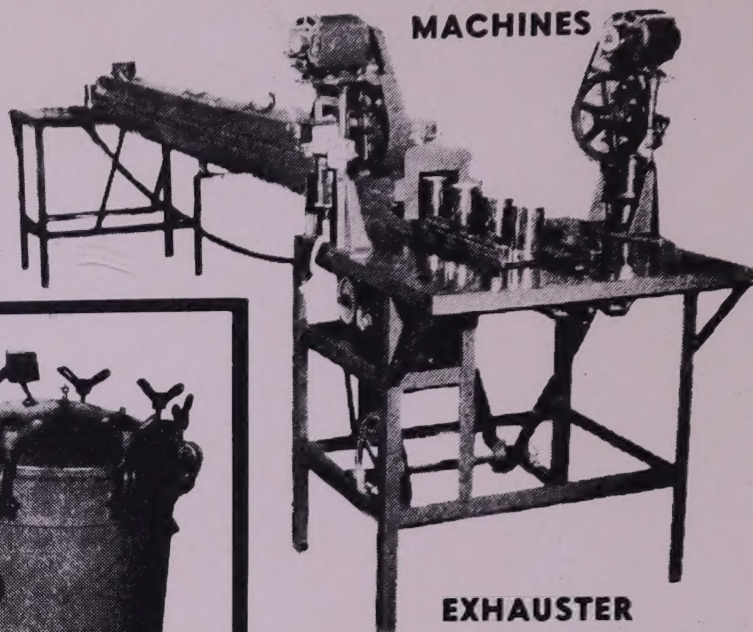
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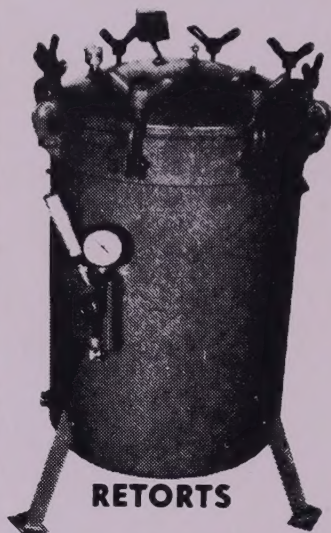
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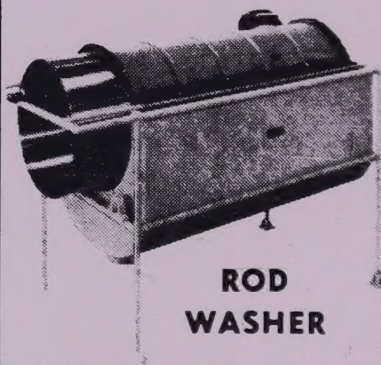
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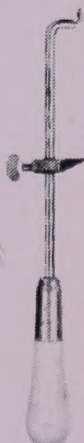
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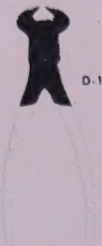
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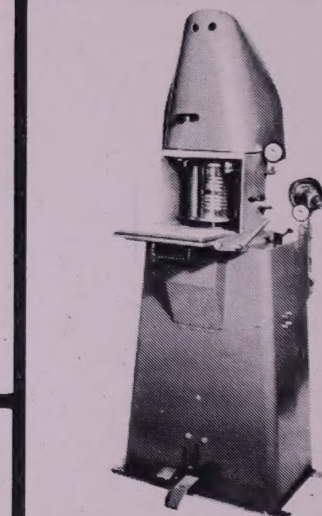
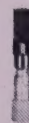
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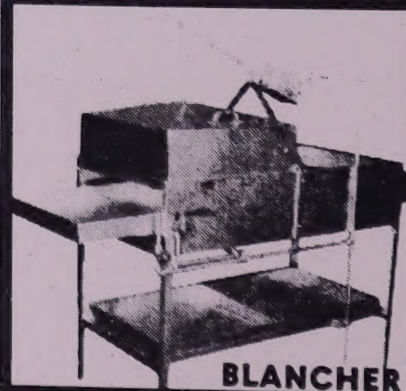
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JOURNAL
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INSTITUTE AFFAIRS – AFFAIRES DE L'INSTITUT

From the President's Desk

In commencing my year at the "President's Desk" I would like to express our thanks once again to Martin Stauvers for all his efforts devoted to the Institute during his term as President.

CIFST is continuing to grow. However, this net increase in membership obscures to some extent the large turnover in members. New members replace those who discontinue their membership for a variety of reasons. We must continue to examine the goals and performance of the Institute to make certain it is responding to the needs of the members. As the Institute matures there will, of course, be some growing pains; however we are making excellent progress.

Art Greene's first term as Executive Director has been most valuable for the CIFST and his handling of the Institute's business is to be commended. As the National Office evolves, it becomes apparent that there are several functions of the Institute that would be very efficiently and effectively handled by the Executive Director, including some of the functions presently handled by the local conference committees and other national committee chairmen. Transfer of many tasks to the National Office will occur as we move towards having a full time Executive Director.

There are many exciting challenges ahead for the CIFST; how can we help to keep Canadians informed on matters of food and nutrition, how can CIFST respond to the dissemination of misinformation and what role can we play in the shaping of government policy? These matters require our commitment as individual members as well as collectively through the Institute and I welcome your comments and suggestions.

Preparations for the 1983 Conference in Ottawa are well in hand under the able guidance of Conference Chairman Alex Hunt. Alex's committee is preparing both a technically stimulating as well as socially rewarding conference.

I am looking forward to my visits to the sections this autumn and the occasion this presents to meet with as many of the members as possible. I would like to extend an invitation to all members to visit the National Office if they have the occasion to be in Ottawa. The various section presentations are displayed and provide an appropriate reminder of the national scope of our organization.

G.E. Timbers

News from the Sections

People in the News

New student members who have recently joined the CIFST are: **Ann Burns-Tardif, Josephine Deeks, Paul Lafleur, Sylvie Nadon, Lydia Radzevicius and Virginia Reimer**, all members of the **Ottawa Section**. . . . **Carol Reid** has become Quality Control Manager, and **Naresh Goyal** Director of Research, at Sun-Rype. . . . **Dr. N.A. Michael Eskin**, Professor and Head of the Department of Foods and Nutrition, University of Manitoba, is the recipient of a Lady Davis Fellowship Award at the Department of Biotechnology and Food Engineering,

Technion Haifa, Israel. Dr. Eskin will be taking a study leave as of July 1 to take up the fellowship as visiting professor later this year.

Ottawa Section Holds Meeting with Four Other Professional Associations

A joint meeting of the CIFST Ottawa Section, the Ontario Dietetic Association and the Ottawa Home Economics Association, Ontario Institute of Agrologists and Canadian Chefs de Cuisine was held on March 17th. It was actually a dinner meeting with catering provided most expertly by the chef's school at Algonquin College. After a happy hour, Mr. Marcel Kretz, who captained the Canadian team at the 1980 Culinary Olympics at Frankfurt, Germany, showed a film of the week long event. Canada placed third, one of the entrées being buffalo steak. Marcel is the Head Chef at La Gapinière, in the Laurentian ski area north of Montreal. After dinner, Pat Johnson chaired a panel which looked at food production from plant breeding through to the nutritional quality of cereals. Dr. Vern Burrows, from the Ottawa Research Station, led off with some fascinating statistics. Of about 350,000 species of plants, 300 have some agricultural significance but only twenty are of major importance to humans. Of the twenty, eight are cereals. Humans get from 56-60% of their calories and 50% of their protein from these cereals. Canada has the capacity to increase production but the problem remains to get a reasonable return to producers. Anita Stanger of the Food Advisory Division, Agriculture Canada, traced the development of a man-made cereal, triticale, which is a cross between rye and wheat. She described the limitations on use and the way some of the problems have been resolved in recipes. This cereal has a place in spite of its drawbacks because of its disease resistance and general hardiness, like its rye parent. Dr. John Holme of the Food Research Institute, Agriculture Canada, looked at the processing of cereals from the perspective of benefits derived. He spoke of preservation, creation of new products and the preparation for consumption as common types of processing. Some of these improve the safety of products while others destroy nutrients which must be replaced. Jean Armstrong from the University of Ottawa spoke of the value of cereals as economical sources of nutrients and as sources of fibre. During a question and answer session, panelists elaborated on the value of cereals to the world food supply.

John Kitson Retires

Long-time CIFST member and Eva Award winner John Kitson has officially retired from service with Agriculture Canada. While John is no longer "gainfully employed" with the Federal Government, it is not entirely correct to say that he is retired. In fact, for those who have worked with John, it is just as difficult to find him home as it ever was. He has just returned from Bogota, Colombia, where he has been working through CIDA on a development project designed to improve food preservation systems in that country.



John Kitson

Best wishes go out to John in his retirement and in his new ventures in the private consulting field.

Ottawa Student Group Has Busy Year

The University of Ottawa Student Chapter has gotten off the ground with a full year of fun and activity. Many of the food and nutrition students started the academic year on the right foot by attending the Ottawa Section's Septemberfest party. In mid October, they had the pleasure of hearing Frances Moore Lappé (*Diet for a Small Planet*) talk on campus about nutrition planning in the developing world. More recently, the students organized their annual "Meet the Professors" evening. Useful discussions over academic programs, career counselling, and industrial opportunities were held. In March, a food industry tour was held at Silverwood's fluid milk processing plant in Ottawa. The group had an excellent guided tour by Mrs. Marjana Peterman, the plant manager. Most impressive was the compact layout of the HTST equipment and the quality control lab.

Alberta Section Contributes to Agriculture Week Program

Agriculture week was held February 22-26, 1982. The theme was entitled "Bridging the Gap." Alberta Section CIFST contributed to the functions by hosting an open forum to discuss the topic "A Fair Cost for Food - What Contributes to the Price." The guest speakers were Brenda Brindle, food scientist and economist with Ken Agra Services Ltd., Edmonton, Lynn Malmberg, grain farmer and economist from Carstairs, Alberta, and George Winter, Dean, Instructional Services, Olds College. The panel addressed the facts and conditions that affect food prices. There were opportunities for questions and time for discussion.

Alberta Students Receive Awards

At the annual student night meeting of the Alberta Section, a number of deserving students were presented with various scholarships and awards. The recipients were as follows: Canadian Food Industry Scholarships - Diedre Aldcorn, Wilma Koersen, Janice Sych, Colleen Walton, Wendy Wismer; N.A. Larsen Memorial Scholarship - Wilma Koersen; Industrial Work Experience Bursaries - Linda Harris, Sandra Howell, Bonnie Jensen, Colleen Walton, Wes Merta; CIFST (Alberta Section) Scholastic Achievements Award - Jennifer Loyer.

Central British Columbia Members Petition for Full Section Status

By the time this is published, we may have a new section. A very energetic core group from the southeastern region of British Columbia (centred in the Okanagan Valley) has made the decision to approach Council for ratification as a full-

fledged section of CIFST. A very successful program over the past year, capped by a visit from past president Martin Stauvers, gave the group the impetus necessary to proceed. The group has functioned as a subgroup to the British Columbia Section and has received much encouragement from the Vancouver based members. Since no name, boundaries, etc., have yet been decided, readers must "stay tuned" for more in coming issues. In the meantime, this group is wished the best of luck from the Institute as a whole.

D.B.C.

Student Affairs News

The Student Affairs Committee (SAC) conveys its greetings to all CIFST student members across Canada.

Student representatives from local sections have reported good participation in CIFST activities across Canada. Activities have included: symposia (e.g., Atlantic Section: a symposium on careers in food science and food engineering; Alberta Section: a student presentation on exchanges occurring with the International Association for the Exchange of Students for Technical Experience; Quebec City Section: a symposium on packaging and its direction in the future; British Columbia Section: a student sponsored meeting entitled "Beyond Nutrition - An Interest Dilemma"), workshops on topics of current interest (e.g., Montreal Section: computers applications in the food industry), and visits to different sectors of the food industry (e.g., Guelph Section: a visit to the food industry in Windsor; Southern Ontario Section: a visit to Blenheim's mushroom farm). Some sections have also participated in exchange programs (e.g., a student exchange between students at the University of Alberta and Macdonald College).

The current interest in CIFST student activities certainly indicates the benefits of a student membership. A student membership is not only low in cost, but also provides great opportunity for interaction on research ideas at both the graduate and the undergraduate levels, contact with industrial and governmental representatives, as well as a method of keeping informed of events occurring in food science across Canada.

This year the Institute celebrated its 25th anniversary at Montreal's Queen Elizabeth Hotel between May 30th and June 3rd. In keeping with the conference theme of "Expansion," the student package highlighted a student symposium entitled "Canadian Food Technology; Develop or Import?" The issue of developing or importing technology faces all Canadian food industries and was treated thoroughly by the following speakers:

Dr. Dan Cumming (Research Scientist, Food Processing Section, Agriculture Canada, Summerland, B.C.)

Topic: Developing Canadian Technology

Mr. Neil Hoyland (President, Tetra Pak Inc., Markham, Ont.)

Topic: Importing Technology

Mrs. Carol Clow (Co-director of the Hereditary Metabolic Disease Unit, Montreal Children's Hospital, Montreal, Que.)

Topic: The Canadian Food Bank: A Step Ahead

To complement the student symposium, a Business Interaction meeting was organized to enable representatives from the Meat and Bakery Councils, and the Quebec Dairy Council to discuss employment opportunities in Research and Development, Quality Control/Quality Assurance areas of the food industry. In addition, SAC provided further information on career opportunities in food science and technology at their information booth, and presented the tape-slide show entitled "Food Science Across Canada."

The Student Awards Competition enabled students to present papers on their own research. Interest in the Graduate Paper Competition was overwhelming. At least twenty-five graduate students entered the competition, indicating a healthy interest in research in food science and technology across Canada.

The Graduate Student Paper Competition (\$300.00) was won by Vince Molund, and the Undergraduate Student Paper Competition (\$200.00 plus financial assistance with travel expenses) was won by Sylvain Gauron.

Social activities for students at the Montreal Conference commenced on Sunday afternoon with a student mixer-buffet. Students registered for the total conference package had access to all conference social activities.

Any additional information on the Montreal Conference can be obtained from Nancy Crowe and Helene Deutsch, Co-chairpersons of the Student Conference Committee, at the following address: School of Food Science, Box 285, Macdonald Campus of McGill University, Ste. Anne de Bellevue, Quebec H9X 1C0.

This year all local sections were well represented by their student representatives. All the representatives are to be congratulated for their cooperation and participation in student activities in the CIFST. They are:

<i>British Columbia Section</i>	<i>Guelph Section</i>
Ms. Marcia Nikolaiczuk	Ms. Cathy Airth
Mr. Darrel Chin	<i>Western Ontario Section</i>
	Ms. Kathy Emery
<i>Alberta Section</i>	<i>Quebec Section</i>
Ms. Sara Weinraub	<i>Montreal Section</i>
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Mr. Bob Tyler	Ms. Sylvie Morisset
<i>Manitoba Section</i>	<i>Atlantic Section</i>
Mr. Bob Myhara	Ms. Bridget Kelly
<i>Ontario Section</i>	<i>Newfoundland Section</i>
<i>Toronto Section</i>	Ms. Susan Cave
Mr. Ettore DiBiagio	

The SAC is represented by the following members:

	Gilles Doyon
	(Université Laval)
	Michael Hincks
	(University of Guelph)
Professional Member –	Eileen Neill
	(Agriculture Canada)
Vice Chairperson	– Mirella Cerrone
	(University of Alberta)
Chairman	– David McPeak
	(McGill University)

All the committee members are interested in furthering student participation in CIFST activities. If you have suggestions on increasing student involvement at CIFST meetings (local or national), comments on CIFST membership or student awards, please contact one of the SAC members or talk to your local section representative who will act as liaison to the committee.

D. McPeak
Chairman

CIFST 25 Year Members

In looking at our membership list, the Membership Committee noted that there were a significant number of members who have continuously been members of the Institute for 25 years or longer.

The members who have supported the Institute for 25 years or more are listed below. Their support and loyalty are much appreciated by the Institute.

Ainsworth, F.	Baker, B.	Brochu, E.
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Andrich, G.	Belanger, A.	Clark, D.S.
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Fuller, G.W.	MacInnes, I.A.	Semmons, F.F.
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Gitelman, P.	Mason, W.	Taylor, D.W.
Goldschmied, G.	McLeod, A.G.	Theroux, M.N.
Gregory, N.L.	McPeak, J.	Torrie, K.M.
Harper, E.	Miller, H.	Wells, J.O.
Hughes, R.B.	Moreau, J.R.	Wenzel, J.S.
Hulse, J.	Phillips, N.A.	Williams, G.J.

1982-83 Speaker's List

Each year the Speaker's Bureau committee prepares a list of speakers who are prepared to address CIFST section meetings. The Speaker's Bureau committee has a small budget which can be used to aid in the cost of travel and accommodation for the speaker. This list is sent to each of the sections to assist in preparations for their technical programs.

Any member wishing to provide services as a speaker can contact: Robert C. Jenne, Libby McNeill & Libby Co., 330 Richmond Street, Chatham, Ontario N7M 1P7. Telephone: (519) 352-4400.

The members and their topics for 1982-83 are:

Bligh, Dr. E.G., Director, Fisheries Research and Technology Laboratory, Nova Scotia Technical College, P.O. Box 1000, 1360 Barrington Street, Halifax, Nova Scotia B3J 2X4, (902) 429-8300.

1. *New Challenges in Seafood Research*

Brisson, Dr. G.J., Nutritional Research Centre, Laval University, St. Foy, Québec G1K 7P4, (418) 656-7660.

1. *Nutritional Value in New Protein Sources*
2. *Problems with Additives in Animal Feed and with Residues in Meats*
3. *Role of Industry in the Nutritional Quality of Foods*
4. *Lipids in Human Nutrition*

Clark, Dr. D.S., Director, Bureau of Microbial Hazards, Food Directorate, Health Protection Branch, Department of National Health and Welfare, New Research Centre, Tunney's Pasture, Ottawa, Ontario K1A 0L2, (613) 593-7071.

1. *Sampling of Foods for Microbiological Analysis*
2. *International Microbiological Standards*

Clark, Mr. J.N., Director, Sales and Technical Services, Stange Canada Inc., 3340 Orlando Drive, Mississauga, Ontario L4V 1C7, (416) 678-1220.

1. *Good Nutrition is Good Business*
2. *New Food Product Development*

Cumming, Dr. D.B., Research Scientist, Food Processing Section, Agriculture Canada Research Station, Summerland, British Columbia V0H 1Z0, (604) 494-7711.

1. *Food Additives, Facts and Fallacies*
2. *The Development of New Process Systems – A Case Study on Blanching*

Hauschild, Dr. A., Research Scientist, Microbiological Division, Food Research Laboratories, Health and Welfare Canada, Tunney's Pasture, Ottawa, Ontario K1A 0L2, (613) 996-2634.

1. *Critical Aspects of Food Preservation in the Control of Clostridium Botulinum*

Idziak, Dr. E.S., Professor of Microbiology and Food Science, Department of Microbiology, Macdonald College, Quebec, Quebec H9X 1C0, (514) 457-2000.

1. *Principles of Microbiological Food Safety Assessment and Problems in Isolating Indicator, Index and Pathogenic Organisms*
2. *Microbial Antagonism – Significance in Food Preservation*

Jelen, Dr. P., Associate Professor, Department of Food Science, University of Alberta, Edmonton, Alberta T6G 2P5, (403) 432-2480.

1. *Food from Waste and Unconventional Sources*

Küson, Mr. J.A., Food Processing Section, Agriculture Canada Research Station, Summerland, British Columbia V0H 1Z0, (604) 494-7711.

1. *Food Engineering Developments at Agriculture Canada Research Station, Summerland, British Columbia*
2. *Fifty Years of Food Processing Research at Summerland*
3. *A Food Technologist Looks at China (1981)*

Lowrie, Dr. R.J., Provincial Cheese Specialist, Dairy Division, Alberta Agriculture Provincial Building, 5201 – 50th Avenue, Wetaskiwin, Alberta T9A 0S7, (403) 352-1227.

1. *Cheese and Cultured Dairy Products, Starter Cultures, Bacteriophages of Lactic Streptococci, New Bulk Culture Techniques, Cheese Flavour, etc.*
2. *Cutting Starter Costs Without Cutting Corners – Recent introduction into Alberta cheese factories of the new method for preparing bulk starters using pH control and whey-based media has been very successful.*

Moreau, Dr. Jean-R., Professor of Biochemical Engineering, Department of Chemical Engineering, Laval University, Quebec, Quebec G1K 7P4, (418) 656-2903.

1. *Control of Bacterial Factors Involved in the Preservation of Food*
2. *Nitrosamines in Relation to Cured Meats*
3. *Quality Factors Involved in Meat Production*
4. *Quality Factors Involved in Meat Preservation*

Powrie, Dr. W.D., Professor and Head, Department of Food Science, University of British Columbia, Vancouver, British Columbia V6T 2A2, (604) 228-3404.

1. *Food Additives – Why?*
2. *Plant Proteins for Human Food*
3. *Approaches to New Product Development*
4. *Capturing Food Quality by Freezing*
5. *A Daily Allotment of Nutrients*
6. *Carcinogens in Our Food*
7. *Safety in Our Food Supply – A Practical Approach*

Riel, Dr. R.R., Research Co-Ordinator (Food), Research Branch, Agriculture Canada, Central Experimental Farm, Ottawa, Ontario K1A 0C5, (613) 995-7084, Ext. 321.

1. *Energy and Food*
2. *World Food Protein Resources*
3. *A Food Strategy for Canada*

Ross, Mr. C.J., Manager, Scientific Research, Canadian Canners Ltd., Research Centre, 1101 Walker's Line Road, Burlington, Ontario L7N 2G4, (416) 335-9700.

1. *Treatment and/or Disposal of Food Plant Wastes and Liquid Waste Effluents*
2. *Nutrition of Canned Foods*
3. *New Product Development in the Canning Field*
4. *Packaging, Labelling and Regulations for Canned Foods*

Somers, Dr. E., Director General of the Environmental Health Directorate, Health Protection Branch, Health and Welfare

Canada, Environmental Health Centre, Tunney's Pasture, Ottawa, Ontario K1A 0L2, (613) 995-6015.

1. *Environmental Hazards, Risk Assessment and Acceptability*

Stiles, Dr. M.E., Faculty of Economics, University of Alberta, Edmonton, Alberta T6G 2M8, (403) 432-5239.

1. *The Gap Between Food Manufacturing and the Consumer*
2. *The Reliability and Meaning of Bacterial Counts in Food Products*

Strachan, Dr. G.E., Research Scientist, Food Processing Section, Agriculture Canada Research Station, Summerland, British Columbia V0H 1Z0, (604) 494-7711.

1. *The Improvement of Canadian Wines Through the Evaluation and Selection of Grapes Better Suited to Canadian Growing Conditions*
2. *Improvement of Flavour, Colour and Aroma of Wines Through Improved Vintning Techniques*
3. *The Improvement of Industrial Fermentations by Genetic Modification of Micro-organisms*

Tape, Dr. N.W., Director, Food and Nutrition Service, Food Production and Marketing Service, Agriculture Canada, Room 643, Sir John Carling Building, Ottawa, Ontario K1A 0C5, (613) 995-5880, Ext. 237.

1. *Integrating Nutrition in Food and Agriculture Programs*
2. *Issues Relating to Canada's Food R & D Capability*
3. *Food Additives – Risk or Benefit?*

Townesley, Dr. P.M., Department of Food Science, University of British Columbia, Vancouver, British Columbia V6T 2A2.

1. *Western Canadian Biotechnology*

van den Berg, Dr. L., Principal Research Officer, Head, Biological Production of Fuels of Biological Sciences, National Research Council, 100 Sussex Drive, Ottawa, Ontario K1A 0R6, (613) 992-3310.

1. *Quality Maintenance in Fresh Vegetables During Winter Storage*
2. *Methane Production from Food Processing Wastes*

University Activity Reports

University of Manitoba

Department of Food Science

Like many other food science programs in Canada, the one at the University of Manitoba developed from a dairy science department that was founded in 1904. During the past year the undergraduate program attracted about forty-five students while the graduate enrollment was twenty-five, all at the master's level. A new Ph.D. program is in the final stages of implementation. Permanent employment for graduates from these programs, as well as summer work experience for undergraduates, has been facilitated greatly by Mr. George Andrich (a former CIFST president), serving as a student-industry placement officer.

The overall research program of the department continues to build in specific areas judged to be of existing or future potential within the province. Considerable effort is expended on the biochemistry of starchy legumes, with a view to increasing the utilization of these materials in human diets. A large horticultural program focuses on the use of various biochemical, sensory and microstructural techniques in the characterization of product quality. Activities include a joint involvement with other prairie provinces in a potato cultivar evaluation program as well as development work on certain vegetables (peas, corn, lettuce). Although this program entails some service work, numerous spinoff research programs also arise from it.

The development of processing technology for provincially grown products is an area of continuing activity. Recent studies on silverskin onions have assisted in the establishment of a com-

mercial plant. Research on the Jerusalem artichoke is attempting to use ultrafiltration technology to produce fructose from the inulin-containing tubers. A food microbiology program relating to inhibition of microbes by naturally occurring food components is just developing.

To assist the various research programs, and also to add realism to teaching sessions, the department maintains two pilot plant facilities. One is primarily for solid products (mainly of plant origin) while the other is used for bulk fluids (milk and juices). Students are introduced to these facilities as early as second year. A further enrichment of teaching programs with some business administration skills plus microcomputer technology is designed to produce graduates with a sound food science knowledge base plus peripheral skills to encourage efficient assimilation into various working environments.

E.D. Murray

Department of Foods and Nutrition

The Department of Foods and Nutrition in the Faculty of Human Ecology enjoys a strong program in foods and nutrition teaching and research which is widely recognized across Canada. The recent change in the faculty name, together with the revised undergraduate program, resulted in a doubling of the number of students entering the department, from thirty-two to sixty-four. While the majority of the students have traditionally followed the dietetics route, at least one-quarter have entered the Nutrition and Foods stream. A new program introduced last year is the Food Service Management stream which has already attracted a number of students. These students will be encouraged to take a minor in administrative studies, which will provide them with a combination of food science and management skills together with a background in nutrition.

In addition to the four year undergraduate program, the department has a well established graduate program consisting of twenty students pursuing M.Sc. degrees in foods and nutrition. A recent emphasis has been in the community nutrition area and several graduate students received CIDA fellowships which permitted them to carry out projects in Thailand and British Guiana. Research in the foods area, particularly in sensory evaluation, enjoys both a national and international reputation. This expertise is widely sought and has resulted in a number of sensory evaluation workshops being offered by the department over the past few years. Several faculty members are involved in food chemistry research and their work in the development of new methods in food analysis is widely recognized. Research carried out in nutritional biochemistry, particularly with human metabolic studies, is unique in Canada. A particular emphasis by the department has been in the lipids research area. The total research funding received by the department in 1981-82 was over \$250,000 and includes government, foundation and industrial support. The recent approval of an interdepartmental Ph.D. program in food and nutritional sciences, in cooperation with the Departments of Food Science, Plant Science and Animal Science, should permit more in depth research than has previously been possible.

In addition to its research program, the department offers a food testing service and has successfully carried out a variety of assignments for the food industry in the areas of product testing and development. Several members of the department were involved in testing for the detection of sodium amyltal in coffee, and were called by the Crown as expert witnesses at the Katy Harper trial this year. The department looks forward in the near future to developing greater international links with institutes in developing countries as part of its role in helping to solve food and nutrition problems.

N.A.M. Eskin

Aspartame Summary

Effective August 12, 1981, a new, low calorie sweetener

called aspartame was approved for use in a variety of processed food products in Canada. Approval of aspartame has been given for use in tabletop sweeteners, breakfast cereals, beverages, beverage concentrates and beverage mixes, desserts, dessert mixes, toppings, topping mixes, fillings, filling mixes, chewing gum and breath freshener products. Aspartame will also be permitted for use in drugs and cosmetics.

Aspartame is a man-made sweetener, composed of two amino acids, L-aspartic acid and L-phenylalanine. These amino acids are building blocks of protein and are absorbed by the body in the same way as other proteins in food.

Compared to sugar, aspartame is approximately 200 times sweeter. One teaspoon provides one-tenth of a calorie compared with eighteen calories in a teaspoon of sugar. Unlike sugar, when exposed to high cooking temperatures or very acidic foods, aspartame breaks down and becomes less sweet. It is not, therefore, suitable as a sugar substitute for baking or preserving.

The safety of aspartame has been studied extensively in laboratory tests involving a wide range of animal species including rats, mice, dogs and monkeys. Tests using animals are an internationally accepted means of determining human health hazards from substances like aspartame. In addition to animal tests, the safety of aspartame has been confirmed in several studies with human volunteers. The safety data available on aspartame has been extensively studied by both Health and Welfare Canada and by international agencies such as the Food and Agriculture Organization/World Health Organization Joint Expert Committee on Food Additives.

There is, however, a small segment of the Canadian public, approximately 250 persons, who may find it necessary to restrict their aspartame consumption because they suffer from a metabolic disorder known as Phenylketonuria or P.K.U., a hereditary metabolic disorder. Infants born with this disease lack the ability to produce the enzyme necessary to metabolize phenylalanine, one of the two amino acids comprising aspartame.

For those individuals afflicted with P.K.U., it is very important they be aware that aspartame contains phenylalanine. The labels of aspartame-containing products will provide this information by stating the following:

- a statement on the front panel that the product contains aspartame;
- grouped elsewhere on the label, a list of the protein, fat, carbohydrate and aspartame content and a statement of the energy value (in calories) of the product; and
- a statement that aspartame contains phenylalanine and; on tabletop sweetener packages, the amount of the sweetener that is equivalent to a specified amount of sugar.

Overview of Food Processing, Distribution, Retailing and Food Service Sectors

Editorial Note: The following article was excerpted from a booklet produced by Agriculture Canada entitled *Canada's Agri-Food System - An Overview*.

F.R.V.

The Food and Beverage Processing Industry

The food and beverage processing industry is Canada's largest manufacturing industry. In 1978, 4,535 plants had shipments of \$22 billion which was 17% of total manufacturing shipments. The industry employed 230,000 people, 12.8% of manufacturing employment. Purchases of materials and supplies, most of which were of agricultural origin, totaled \$14.8 billion.

Within the food and beverage sector there are eighteen separate industries, ranging in size from slaughtering and meat processing (employing 34,800 with a value added of \$1 billion in 1978) to wineries (employment at 1,200 and value added \$62 million) (Table 1).

Institute Affairs / v

Table 1. The processed food and beverage industry, selected statistics, 1978.

Commodity	Establishments (no.)	Manufacture value added (\$ million)	Total employment ('000)
Meat and poultry products	578	1,161.4	44.2
Slaughtering and meat processors	491	952.8	34.8
Poultry processors	87	208.6	9.4
Fish product industry	347	480.2	25.2
Fruit and vegetable processing industries	232	460.7	17.4
Fruit and vegetable canners and preservers	197	372.6	13.5
Frozen fruit and vegetable processors	35	88.1	3.8
Dairy product industry	485	823.6	27.0
Flour and breakfast cereal product industry	49	198.6	5.2
Feed industry	593	303.2	9.2
Bakery product industry	1,475	672.4	33.5
Biscuit manufacturers	35	151.5	7.1
Bakeries	1,440	520.9	26.4
Miscellaneous food industries	417	1,336.8	35.3
Confectionery manufacturers	106	293.2	9.0
Cane and beet sugar processors	15	109.4	2.9
Vegetable oil mills	10	54.9	1.2
Miscellaneous food processors	286	879.3	22.2
Beverage industries	359	1,483.9	32.9
Soft drink manufacturers	255	401.2	14.6
Distilleries	34	374.2	5.2
Breweries	41	646.2	11.9
Wineries	29	62.4	1.2
Total food and beverage	4,535	6,920.9	229.9

In assessing the relative sizes of industries the concept of value added is useful. This is essentially the value added by the processing activity to purchased materials and supplies and reflects the degree of processing (Table 1).

The food and beverage processing industry is an important contributor to the provinces' economies (Table 1). Value added by the food and beverage industry in relation to all industries ranges from about 12% in Ontario, Quebec, and British Columbia to 24% in the Prairie Provinces and 30% in the Atlantic region.

The size of establishment in the industry varies widely. Nearly 50% employ fewer than ten workers while about 1% employ more than 500. A few exceed 1,000 workers.

In addition to food and beverage processing, manufacturing industries such as tobacco and leather goods use agricultural products.

The Marketing and Distribution System

The task of getting crops and livestock from the farm to the food processor and then to the consumer involves buying and selling, transportation, storage, financing, and risk-taking. Fresh produce may go from the farm to the consumer directly or through the wholesaling and retailing system.

The methods used for establishing prices include auctions, marketing boards, terminal markets, brokers, wholesalers, co-operatives, and direct sales. The markets can be local, national, or international; the products can be perishable, storable, fresh, or processed; and the marketing-distribution system can be tailored to meet these requirements.

The overall size of the marketing-distribution system is difficult to measure. One reason is the diversity of operations involved, with many marketing-distribution functions being performed by food processors and food retailers, especially the

larger ones. Some data on the wholesaling of farm and food products are shown in Table 2. Farm and food products together account for about one-quarter of all wholesale trade.

Food Retailing

Total food store sales in 1980 were \$20.2 billion, about one-quarter of total Canadian retail sales (Table 3).

In 1980 there were 32,033 retail food stores in Canada. They included supermarkets, convenience stores, super-stores (large food stores), combination stores (which sell food and nonfood items such as small appliances), warehouse stores (box stores), limited assortment stores, and specialty stores (e.g., health food and cheese shops). The increasing variety of store types represents the retailers' efforts to reduce costs while meeting consumer demands for low prices, quality, variety, and convenience.

According to the *Canadian Grocer*, chains (four or more stores under one name) operated 1,605 supermarkets and 2,385 convenience stores. They accounted for 60% of total food store sales. Independents operating under wholesaler-sponsored programs (such as I.G.A.) operated 9,221 stores and accounted for 27% of total sales. Unaffiliated stores comprised the remainder.

Table 3. Canadian food retailing, 1980.

Store organization	Establishments (no.)	Sales (\$ billion)
Chains	3,990	12.1
Voluntary group stores	9,221	5.4
Unaffiliated stores	18,900	2.7
Total	32,033	20.2

The Food Service Sector

The food service sector includes a commercial subsector (e.g., restaurants and bars) and a noncommercial subsector (e.g., hospitals and the armed services).

The value of food provided by the food service sector in 1978 has been estimated at about \$10 billion, of which \$6.8 billion was in the commercial subsector. Restaurants accounted for approximately 67% of the commercial subsector's food sales and 62% of its alcoholic beverage sales.

Table 2. Farm product and food wholesaling, 1977.

Product	Establishments (no.)	Value of purchases (\$ million)	Volume of sales (\$ million)
Farm products	396	5,291	6,200
Food	1,957	10,198	11,611

Table 4. The commercial food service sector, 1978.

Kind of food establishment	Food establishments (no.)	Sales of meals and lunches (\$ million)	Sales of alcoholic beverages (\$ million)
Restaurants	20,359	3,715	694
Licensed	9,295	2,181	694
Unlicensed	11,064	1,534	-
Drive-in outlets	1,101	290	-
Take-out shops	4,227	820	-
Caterers	1,340	615	3
Refreshment stands	2,131	117	-
Beverage rooms, bars and nightclubs	2,453	24	426
Total	31,611	5,581	1,123

In 1978 the commercial subsector of the food service industry comprised 31,611 establishments. Restaurants accounted for 64%; take-outs 13%; beverage rooms, bars, clubs, etc. 8%; refreshment stands 7%; caterers 4%; and drive-ins 4%.

One of the industry's recent changes has been the growth in chains featuring limited menus. Between 1971 and 1978, chain restaurants increased their share of the restaurant business from 10.4-22.5%. With one-third of all meals being eaten away from home, the rest of the food system must be able to meet the specific quantitative and qualitative demands of these chains and the other food service outlets.

Food Consumption and Expenditure

Canadians spend about 18% of their personal disposable income on food and nonalcoholic beverages. In recent years this percentage, the second lowest in the world after the United States, has remained fairly constant. In absolute terms, expenditures have increased as a result of rising food prices, but incomes have also been increasing.

Expenditures on particular food items change in response to changes in relative prices, incomes and tastes. Between 1969 and 1978, increases in expenditures on nonalcoholic beverages, fats and oils, and frozen foods were relatively large, whereas expenditures on some foods, most notably eggs, decreased.

The share of total food expenditures made away from home has increased from 22% in 1969 to over 30%. These expenditures are characterized by a higher share being spent on meat, and smaller shares on dairy, fruit, and vegetables, compared with expenditures on food consumed at home.

These data, however, apply to average families. Families with lower incomes, senior citizens, single parents, and wives who do not earn income spend a larger proportion of their personal disposable income on food. For example, low income families spend 30% of their disposable income on food, compared with 16% for high income families. In terms of the food dollar allocation among the various food groups, the lower income families spend more on cereal and bakery products, fats

and oils, and beverages and less on meat and frozen food.

Expenditure data reflect the effects on changes in both quantities consumed and prices. The quantities consumed per person of red meats, fish, poultry, specialty and process cheese, fats and oils, and fresh and processed fruit and vegetables has increased somewhat since 1970, while that of eggs and dairy products (creamery butter, evaporated whole milk, ice cream and skim milk powder) has decreased. The consumption of cereals and beverages has remained stable.

Total food demand in Canada is likely to keep pace with population growth, perhaps 1-1.5% a year. Worldwide, however, significant increases in food demand are expected.

International Trade

The value of agricultural exports in 1980 reached \$7.9 billion, while agricultural imports were valued at \$5.1 billion. The dominance of wheat as our major export commodity is apparent in Table 6 where the values of major commodity groups are expressed as percentage shares of total agricultural exports and imports. Four commodity groups comprised slightly more than half of our agricultural imports in 1980. They are fruits and nuts, plantation crops (tea, coffee, cocoa, and rubber), sugar and vegetables. During the past ten years the commodity share of agricultural exports and imports has not changed significantly.

Exports

Table 7 presents Canada's five major agricultural export

Table 6. Canada's agricultural trade in 1980.

Commodity group	Exports (%)	Imports (%)
Grains ¹	57	4
Grain products	4	2
Animal feeds	2	1
Oilseeds	8	4
Oilseed products	3	5
Live animals	3	2
Meats	7	6
Other animal products	5	6
Dairy products	2	2
Poultry and eggs	1	1
Fruit and nuts	1	20
Vegetables	2	9
Potatoes	1	1
Seeds for sowing	- ²	1
Maple products	-	0
Sugar	-	10
Tobacco	1	1
Vegetable fibres	-	3
Plantation crops	-	15
Other agricultural products	3	7

¹Comprises 85% wheat, 9% barley and 6% other grains.

²Less than 1%.

Table 5. The consumer dollar spent for food consumed at home, showing percentages spent on the major food groups.

Commodity	1969 (%)	1978 (%)
Meat, poultry, and fish	34.6	33.1
Fruit and vegetables	16.4	17.3
Dairy products	15.4	14.8
Bakery and cereal products	12.0	11.2
Miscellaneous groceries	7.2	6.5
Beverages	5.5	7.4
Eggs	2.9	1.8
Prepared food	2.5	2.4
Fats and oils	1.8	2.6
Frozen food	1.7	2.9

Table 7. Canada's major export markets for agricultural products.

	Total	China	EEC	Japan	United States	U.S.S.R.	Other
Period	(\$ million)						
1970-79	3,569	260	828	615	569	269	1,055
(% of total)	(100)	(7)	(23)	(17)	(16)	(7)	(29)
1980	7,845	531	1,279	1,057	1,139	1,297	2,542
(% of total)	(100)	(7)	(16)	(13)	(15)	(17)	(32)

Table 8. Canada's major sources of agricultural imports.

	Total	Australia	EEC	Mexico	New Zealand	United States	Other
Period	(\$ million)						
1970-79	2,739	185	204	55	67	1,543	685
(% of total)	(100)	(7)	(8)	(2)	(2)	(56)	(25)
1980	5,107	328	336	84	134	2,913	1,312
(% of total)	(100)	(6)	(6)	(2)	(3)	(57)	(26)

markets. The European Economic Community (EEC) is traditionally our largest market, while the United States and Japan compete for second place, followed by the U.S.S.R. and China. In 1980, however, the U.S.S.R. moved from fourth to first place, becoming Canada's largest agricultural market. This shift was due to substantial increases in the value of grain exports to the U.S.S.R. during 1980.

Imports

Canada's major import suppliers are the United States, Australia, the EEC, New Zealand, and Mexico. The United States supplies over half of our agricultural imports. Table 8 shows that 57% of the total value of our agricultural imports came from the United States in 1980.

Food Trade

Food trade as a component of agricultural trade in the preceding discussion includes agricultural commodities which are processed or ready to eat, such as meat, fruit, nuts, vegetables, tea and refined sugar. It also includes fish products and beverages (including alcoholic), which are not included in agricultural trade data. Food trade does not include agricultural commodities which are either inedible or not yet in an edible form, such as fur, skins, wheat, tobacco, green coffee and raw sugar. Food exports in 1980 were valued at \$3.1 billion and food imports at \$3.4 billion.

Food Buying Trends in the Future

Today's supermarket has come a long way from the corner grocery store, but food retailers in the future will likely have even more changes in store for the food buyer.

Retailers sell the kind of food and in a form that is dictated by the trends, tastes, fads and demands of the society they serve.

In the 1960's and 1970's, in response to population and social changes, retailers developed a multitude of store layouts and services for the public. These included food barns, warehouse stores, convenience stores, discount stores and specialty food stores, specializing to meet the needs of groups and segments within society. Recent studies show this trend will likely accelerate in the near future.

Suburban shoppers are used to the convenience of one-stop shopping. This will probably lead to even greater emphasis on the use of "superstores." These are retail outlets with more than 3,000 sq. metres of floor space and more than 25,000 items in stock. They also carry a large stock of nonfood items. A recent United States study forecasts superstores will have about 25% of the food market by 1985 compared to 15% in

1979. Within thirty years, the "mega-store," with even more space and goods, will probably be a reality.

At the other end of the retail business, small specialty stores, such as fruit and vegetable markets, cheese shops and delicatessens will be moving up to take over about 14% of the food market by 1985 in the United States.

The conventional supermarket in Canada is expected to show the lowest rate of sales increase of all types of retail food outlets in the next few years.

The types of food sold are also changing, with packaged convenience foods and ingredients for cooking from scratch both on the upswing. Although this may be a contradiction in trends, it may be a compromise between time saving and money saving considerations.

Population shifts have a strong impact on what retail food stores sell and Statistics Canada's projection for the population in the year 2001 shows more than one-third of the population will be over forty-five, compared to 27.8% in 1976 and the population under nineteen will drop below 30%. It also projects the ratio of females to males over sixty-five will increase dramatically. The result would be smaller families and an increase in the number of elderly, single women. This could mean retailers would have to sell smaller portions with a lower calorie content per package.

Technological changes will probably have the greatest impact on how food is sold in the future. Tele-shopping may be the trend with the most effect on the food buying public. Items could be displayed on the home television screen and ordered by phone. This could cut the time for weekly grocery shopping to minutes. Computer scanning at checkout counters is likely here to stay and offers advantages to both consumers and retailers, with customers getting faster service, greater pricing accuracy and a more informative receipt, while retailers get more information to develop their merchandising strategy.

New ways of packaging and processing food will also revolutionize the food industry. Ultra-high temperature processing of milk and other foods increases the shelf life of the product and reduces the need for expensive refrigerated shelf space. Retortable pouches made of thin, flexible, laminated materials could be the way of the future for many packaged foods, saving energy and retaining nutrients and flavour. Food labelling is also changing, with no-name brands having caught on with the public, and many retail stores regularly stock these items.

These are only some of the retail food trends that are evident now. Society and technology are changing so rapidly that many other new developments can only be guessed at.

Semi-Refined Canola Oil

A new semi-refined canola oil is now being processed by United Oilseed Products Ltd., utilizing new patent pending technology developed by the company with experimental assistance from the POS Pilot Plant Corporation.

The new grade of oil is the first ever of this quality to be produced by a Canadian canola-crushing plant. When this oil is further refined, it can be done with a physical refining process rather than an alkali-refining process, resulting in lower costs, and providing significant benefits for canola producers, refiners and consumers.

The company has already been able to sell commercial quantities of the semi-refined oil and it will also be able to fully refine the oil to produce canola salad oil for the export market.

Canola-crushing plants have traditionally produced crude and crude degummed canola oil. Both of these oils contain large quantities of phosphorus, which must be removed during the refining process before cooking oil can be manufactured. Removal is by the costly alkali process. The new grade of semi-refined oil contains almost no phosphorus impurities, and can therefore be refined by the lower-cost physical process.

The new oil and its refining process will open the way for new canola oil markets and manufacturing alternatives around the world.

United Oilseed began research in the development of a semi-refined oil in its own laboratories in 1977. Pilot plant experiments were conducted in 1978 at POS, with the assistance of the Agricultural Processing Development Branch of Alberta Agriculture. Scale-up and commercial testing was completed in 1980.

Energy Savings Booklet for the Food Processing Sector

A new publication describing energy saving methods in the food and beverage processing sector now is available from Agriculture Canada.

Titled *Energy Management for Canadian Food and Beverage Industries*, it contains suggestions for saving energy in food processing plants. The publication is a practical energy saving checklist that manufacturers can review when looking for ways to save on their energy bills.

Energy conservation opportunities are listed for boiler and power plant operations, building design and construction, electric power use, fuel management, heating, ventilating and air conditioning, heat recovery, raw product handling and cleaning, refrigeration and weekend shutdowns. In the case of refrigeration alone, there are twenty-five energy saving suggestions a processor could study. In all, the publication lists more than 200 practical ideas for energy savings in food and beverage processing plants. The second part of the publication lists other sources of information on energy savings and assistance available in areas such as tax incentives.

The publication was developed cooperatively by Agriculture Canada's market development directorate and the Food and Beverage Sector Energy Conservation Task Force. The task force consists of representatives from the food and beverage manufacturing industry and from the federal government.

This new publication will be especially useful to managers of small and medium sized establishments who may not be able to afford hiring a consultant to develop an energy management program. With this book, managers will be able to develop their own programs to eliminate energy waste in their plant and increase the effective use of energy in food and beverage manufacturing.

Copies of the publication are available by writing to: Information Services, Agriculture Canada, Ottawa, Ontario K1A 0C7.

New Association

A new association, the Canadian Association of Foodservice Distributors, has been formed. The association is a national body with representation in each province. Member companies are involved in and/or with the foodservice distribution industry.

Some of the association's aims and objectives are:

- (1) To conduct and sponsor research and study programs into matters generally related to the foodservice industry and to affiliate with other organizations, groups or institutes of similar aim.
- (2) To disseminate to its members such information as may be beneficial for the conduct of their business. To provide them with a range of educational services aimed at raising their professional standards and their capacity to serve their clientele efficiently.
- (3) To encourage closer cooperation among members and between them as an organized unit and other organizations and groups seeking improvement of business conditions.
- (4) To promote full acceptance by members of their legal and ethical responsibilities to suppliers, producers and customers and, generally, to uphold the traditions of the industry by maintaining a high standard of business ethics.
- (5) To defend the integrity of the foodservice industry against encroachments or exploitation by outside interests serving ulterior motives.
- (6) To support desirable legislation and oppose undesirable legislation whether at the federal, provincial or municipal level.

The CAFD is a specialized type of trade group and as a new association, wishes to share with other associations and governments the development and comprehension of its overall industry.

Those groups interested in communicating with the CAFD can contact: Elliott J. Besner, Executive Director, Canadian Association of Foodservice Distributors, 750 Laurentien Blvd., Suite 410, St-Laurent, Quebec H4M 2M4.

New Books

Food Industry Wastes: Disposal and Recovery

A. Herzka and R.G. Booth
Applied Science Publishers Ltd. (1981)
246 pp. \$40.00.

N-Nitroso Compounds

R.A. Scanlan and S.R. Tannenbaum
American Chemical Society (1981)
400 pp. \$39.95.

Lipids in Human Nutrition

G.J. Brisson
Jack K. Burgess, Inc. (1981)
175 pp. \$22.50.

Handbook of Geriatric Nutrition

J.M. Hsu and R.L. Davis
Noyes Publications (1981)
372 pp. \$39.00 U.S.

Developments in Meat Science - 2

R. Lawrie
Applied Science Publishers Ltd. (1981)
299 pp. \$64.00.

Biomedical Aspects of Botulism

G.E. Lewis, Jr.
Academic Press Inc. (1981)
366 pp. \$29.00.

Topics in Enzyme and Fermentation Biotechnology. Volume 6
A. Wiseman
John Wiley & Sons, Inc. (1982)
232 pp. \$59.95.

Biological/Biomedical Applications of Liquid Chromatography III. Volume 18
G.L. Hawk
Marcel Dekker, Inc. (1981)
420 pp. \$49.75.

Food Products Formulatory. Volume 1. Meats, Poultry, Fish, Shellfish. Second Edition
L. Long, S.L. Komarik and D.K. Tressler
AVI Publishing Company, Inc. (1982)
459 pp. \$55.00 U.S.; \$60.50 other countries.

Sanitary Techniques in Foodservice. Second Edition
K. Longrée and G.G. Blaker
John Wiley & Sons, Inc. (1982)
271 pp. \$15.50.

Meat, Poultry and Seafood Technology. Recent Developments
E. Karmas
Noyes Data Corporation (1982)
427 pp. \$45.00 U.S.

Combination Processes in Food Irradiation
International Atomic Energy Agency (1981)
467 pp. Austrian Shillings 720,-.

Nutritive Sweeteners
C.G. Birch and K.J. Parker
Applied Science Publishers Ltd. (1982)
316 pp. \$58.00.

Recent Developments in Food Analysis
W. Baltes, P.B. Czédik-Eysenberg and W. Pfannhauser
Verlag Chemie International Inc. (1982)
500 pp. \$61.30 Paperback.

Drying '82
A.S. Mujumdar
Hemisphere Publishing Corporation (1982)
254 pp.

Conferences and Symposia

July 11-14, 1982: 15th Annual Meeting of the Society for Nutrition Education
Boston, Massachusetts. For further information contact: M.J. Feeney, Annual Meeting Coordinator, Society for Nutrition Education, 1736 Franklin St., Oakland, CA 94612.

July 12-16, 1982: XXI International Dairy Congress
Moscow, U.S.S.R. For further information contact: V.A. Grigoriev, Executive Secretary of the Organizing Committee, 35, Lusinovskaya str., 113093 Moscow, M-93, U.S.S.R.

July 22-24, 1982: Triennial Joint Meeting of the American Institute of Nutrition, the American Society for Clinical Nutrition and the Nutrition Society of Canada
University Park, Pennsylvania. For further information contact: American Institute of Nutrition, 9650 Rockville Pike, Bethesda, MD 20814.

July 25-30, 1982: Annual Symposium of the International Microwave Power Institute
San Diego, California. For further information contact: M. Glos, Executive Director, International Microwave Power Institute, 211 E. 43rd St., New York, NY 10017.

August 15-18, 1982: National Soybean Processors Association Annual Meeting
Pebble Beach, California. For further information contact: NSPA, 1800 M St., N.W., Washington, DC 20036.

August 15-18, 1982: 60th Annual Meeting of the National Live Stock and Meat Board
Reno, Nevada. For further information contact: American Live Stock and Meat Board, 444 N. Michigan Ave., Chicago, IL 60611.

August 22-25, 1982: Annual Meeting of IAMFES
Louisville, Kentucky. For further information contact: International Association of Milk, Food and Environmental Sanitarians, Inc., P.O. Box 701, Ames, IA 50010.

August 31-September 3, 1982: IFST (UK) Annual Symposium
York, England. For further information contact: Dr. K.C. Yates, Kellogg Co. (GB) Ltd., Stretford, Manchester, M32 8RA, England.

September 8-10, 1982: CIIA/METE Symposium on Food Industry and the Environment
Budapest, Hungary. For further information contact: Prof. J. Hollo, Central Research Institute for Chemistry, Budapest, Pf. 17, H-1525, Hungary.

September 20-23, 1982: IUFOST Symposium on Food Research and Data Analysis
Oslo, Norway. For further information contact: Dr. H. Martens, Norwegian Food Research Institute, P.O. Box 50, N-1432, Ås-NLH, Norway.

September 21-26, 1982: 14th Biennial IKOFA Exhibition of Food & Beverage Processing, Packaging, & Technical Equipment
Munich, Germany. For further information contact: G.G. Kallman, U.S. Representative, 5 Maple Ct., Ridgewood, NJ 07450.

October 3-6, 1982: POLAGRA-ALIMACH Food Industry Symposium and Exhibition
Olsztyn, Poland. For further information contact: T. Koch, D-ty Director, Foreign Trade Publicity and Publishing Enterprise, ul. Sienkiewicza 12. 00-950 Warsaw, PBO 136, Poland.

October 3-8, 1982: OACS World Conference on Oilseed and Edible Oil Processing
The Hague, The Netherlands. For further information contact: American Oil Chemists' Society, 508 S. Sixth St., Champaign, IL 61820.

October 7-11, 1982: 9th Tokyo International Packaging Exhibition, Tokyo Pack '82
Tokyo, Japan. For further information contact: Yo Kusuda, Secy. Gen., Tokyo Pack, c/o Japan Packaging Institute, Honshu Bldg., 5-12-8, Ginza, Chou-Ku, Tokyo 104, Japan.

October 12-16, 1982: Scanpack 82, Packaging Trade Fair
Göteborg, Sweden. For further information contact: The Swedish Trade Foundation, Box 5222, S-402 24 Göteborg, Sweden.

October 20-23, 1982: InstrumentAsia '82
Singapore. For further information contact: Randle Theobald, InstrumentAsia '82, Overseas Exhibition Services Ltd., 11 Manchester Square, London W1M 5AB, England.

November 29-December 3, 1982: Trade Show for New Technology NOVOTECH
Brussels, Belgium.

December 6-10, 1982: International Conference on Chemistry and World Food Supplies - The New Frontiers
Manila, Philippines. For further information contact: CHEMRAWN II Coordinating Office, International Food Policy

Research Institute, 1776 Massachusetts Avenue, N.W., Washington, DC 20036.

April 25-29, 1983: Brewex '83

Birmingham, England. For further information contact: Terry Brandon, Sales Manager, Industrial and Trade Fairs Ltd., Radcliffe House, Blenheim Court, Solihull, West Midlands B91 2BG, England.

May 24-26, 1983: 37th Annual Quality Congress and Exposition

Boston, Massachusetts. For further information contact: American Society for Quality Control, 230 West Wells Street, Milwaukee, WI 53203.

May 29-June 1, 1983: Canadian Institute of Food Science and Technology Annual Conference

Ottawa, Ontario. For further information contact: Mr. A.A. Hunt, Agricultural Fisheries and Food Products Branch, Industry, Trade and Commerce, 235 Queen Street, Ottawa, ON K1A 0H5.

July 11-15, 1983: International Conference on Gums and Stabilisers for the Food Industry - II. Applications of Hydrocolloids

The North E. Wales Institute, Deeside, Clwyd, United Kingdom. For further information contact: Conference Secretariat, Research Division, The North E. Wales Institute, Kelsterton College, Connah's Quay, Deeside, Clwyd CH5 4 BR, U.K.

July 27-30, 1983: 3rd International Conference on the Instrumental Analysis of Foods and Beverages - Recent Developments

Corfu, Greece. Under the auspices of the Greek Ministry of Agriculture; co-sponsored by the Agricultural and Food Chemistry Division of ACS, the IFT and the Society of Flavor Chemists. For additional information contact: C.J. Mussinan, IFF R & D, 1515 Highway 36, Union Beach, NJ 07735.

August 30-September 9, 1983: XVIth International Congress of Refrigeration

Paris, France. For further information contact: M. Anquez, Director, IIR, 117 Blvd. Malesherbes, 75017 Paris, France.

September 10-16, 1983: ISOPOW III - IUFOST Symposium on Properties of Water in Foods

Dijon, France. For further information contact: Dr. S. Gal, Beethovenstrasse, 11, Gumligen, Switzerland CH-3073.

September 18-23, 1983: VIth World Congress of Food Science and Technology

Dublin, Ireland. For further information contact: Secretariat, Sixth World Congress of Food Science and Technology, 44, Northumberland Road, Dublin 4, Ireland.

August, 1985: XIIIth International Congress of Nutrition

Brighton, England. For further information contact: Dr. D.F. Hollingsworth, Secretary General, IUNS, c/o Institute of Biology, 41 Queen's Gate, London SW7 5HU, England.

Short Courses

July 12-17, 1982: Elementary Short Course in Design and Analysis of Scientific Experiments

Cambridge, Massachusetts. For further information contact: Director of Summer Session Office, Room E19-356, Massachusetts Institute of Technology, Cambridge, MA 02139.

July 19-23, 1982: Controlled Release Technology: Polymeric Delivery Systems for Drugs, Pesticides, and Foods

Cambridge, Massachusetts. For further information contact: Director of Summer Session Office, Room E19-356, Massachusetts Institute of Technology, Cambridge, MA 02139.

July 23-30, 1982: Food Rheology: Principles and Practice
Cambridge, Massachusetts. For further information contact: Professor Chokyun Rha, Room 56-137, Department of Nutrition and Food Science, Massachusetts Institute of Technology, Cambridge, MA 02139.

July 26-30, 1982: Shelf-Life of Foods: Chemical Stability and Safety

Cambridge, Massachusetts. For further information contact: Director of Summer Session Office, Room E19-356, Massachusetts Institute of Technology, Cambridge, MA 02139.

November 15-19, 1982: Canned Foods, Thermal Processing and Container Evaluation

Windsor, Ontario. Tuition fee - \$250.00. For further information contact: Mr. Gary Dmytrow, St. Clair College of Applied Arts & Technology, 2000 Talbot Rd., West, Windsor, ON N9A 6S4.

Workshop

August 15-17, 1982: International Workshop on the Functional Properties of Cereal Carbohydrates

Winnipeg, Manitoba. For further information contact: R.D. Hill, Department of Plant Science, University of Manitoba, Winnipeg, MB R3T 2N2.

Abstracts of Papers Presented at the 25th Annual Conference of the

Canadian Institute of Food Science and Technology May 30-June 3, 1982

LIPOPROTEIN LIPASE INHIBITOR IN COW'S MILK. Al-Salih, A.M.A., Department of Food Science, College of Agriculture, University of Baghdad, Abu-Ghraib, Iraq and M. Anderson, Department of Chemistry, NIRD, Sheffield, Reading RG2 9AT, England.

Large differences were observed in lipoprotein lipase (LPL) stability in milk from individual cows. Differences were also observed in LPL stability in casein and whey. The sum of LPL activity in casein and whey was higher than in the original milk. The activity loss in casein simulated ultrafiltrate (SMUF) suspension was lower than in casein recombined with whey washing of casein with SMUF stabilized LPL activity. The activity was stabilized after dialyzing milk against deionized water or SMUF. Greater loss in activity occurred in diluted samples. Activity was inhibited when casein was resuspended in milk ultrafiltrate but not in SMUF. These results suggest that milk contains an inhibitor of LPL activity.

ERGOSTEROL AND FUNGAL INFECTION IN BROAD BEANS. Al-Shabibi, M.M.A. and S.A. Eedan, Department of Food Science, College of Agriculture, University of Baghdad, Abu-Ghraib, Iraq.

Ergosterol is known as a sterol relatively specific to fungi. Its presence in grains is considered an indicator of fungal invasion. The fungal infection of sun dried beans was studied by thin layer and gas liquid chromatography. Results showed that the ergosterol level was higher in the highly infected beans. Confirmation of presence of ergosterol was established by ultraviolet spectroscopy of sterols obtained from the thin layer chromatoplates. The amount of ergosterol present gave a quantitative estimate of fungal infection.

FERMENTATION OF WHEY FILTRATE BY *SACCHAROMYCES FRAGILIS* FOR THE PRODUCTION OF OIL. Al-Shabibi, M.M.A. and N.A.J. Younis, Department of Food Science, College of Agriculture, University of Baghdad, Abu-Ghraib, Iraq.

S. fragilis was used in the fermentation of cheese whey which was enriched with ammonium and other salts to produce an oil rich biomass. Rapid fermentation rate and lactose utilization was achieved as indicated by the percentage of consumed lactose which varied from 64.5-90.4%. Based on dry weight basis, the fermentation medium had a pronounced effect on yeast yield, total protein and oil production which varied from 22-35.2 g/L whey, 21.7-49.3% and 3.1-22%, respectively.

The fatty acid composition of oil produced also varied with fermentation medium. The oil was rich in 16:0, 16:1, 18:1 and 18:2.

EFFECT OF pH, SALT AND VACUUM PACKAGING ON THE SURVIVAL AND GROWTH OF *YERSINIA ENTEROCOLITICA*. Anger, A. and E.S. Idziak, Department of Microbiology, Macdonald Campus of McGill University, Ste. Anne de Bellevue, Québec H9X 1C0.

Y. enterocolitica is one of the few human pathogens able to grow at refrigeration temperatures. Our study was conducted to determine the effects of various physical and chemical parameters on the survival and growth of this potentially enteropathogenic, food borne bacterium. Four strains were studied – two clinical isolates and two environmental isolates. Low levels of inocula in BHIB were subjected to increasing concentrations of salt (.5% and 9%). After 14 days incubation at 4°C, or 48 h at 25°C, all strains showed greatest growth in .5% NaCl broth; 7% produced a bacteriostatic effect; and 9%, a bactericidal effect. The lowest and highest pH at which the organisms survived were 4.5 and 9.5, respectively, and growth occurred in the range 5.0-9.0. Data on growth and survival of the organism in vacuum packaged meat will also be presented.

MANIPULATION OF THE THERMAL STABILITY OF FABABEAN PROTEIN WITH MOISTURE CONTENT AND IONIC STRENGTH. Arntfield, S.D. and E.D. Murray, Department of Food Science, University of Manitoba, Winnipeg, Manitoba R3T 2N2.

The thermal denaturation of fababean micellar isolate at varying protein to water ratios and in the presence of different salts was investigated using differential scanning calorimetry (DSC). At moisture levels below 1.5 g/g of protein there is an increase in denaturation temperature (Td) with decreasing moisture content accompanied by the appearance of two distinct endotherms corresponding to the two major storage proteins in fababeans. The addition of salts containing monovalent cations increases the Td values and separates the two peaks. Salts containing divalent and trivalent cations have a destabilizing effect as evidenced by lower Td values as well as lower transition enthalpies. The implications of varying water and salt effects are considered.

EXTRACELLULAR HEAT RESISTANT PROTEASES FROM PSYCHOTROPHIC PSEUDOMONADS. Bartlett, F. and T.R. Patel, Department of Biochemistry, Memorial University of Newfoundland, St. John's, Newfoundland A1B 3X9.

Several bacterial isolates from raw milk were found to produce protease(s). Majority of such twenty-eight isolates were Gram negative rods which were oxidase and catalase positive. Nineteen of these isolates were tentatively assigned to genus *Pseudomonas*. Eight of these isolates which showed relatively higher protease activity were chosen for further investigation.

All eight isolates grew in a wide temperature range of 0°C and 35°C and all failed to grow at 37°C. Protease production by all the isolates was detected at all temperatures of growth.

The extracellular proteases from these pseudomonads are heat resistant. The protease activity was detectable even after subjecting the crude enzyme preparation to heat treatment for 10 min at 120°C. Soluble casein is a better substrate for the enzyme than other proteins tested. Besides casein, the enzyme also carried out the hydrolysis of α -N-Benzoyl-DL-arginine-*p*-nitroanilide-HCl (BAPNA), a synthetic substrate used for trypsin like proteases. The optimum pH for the maximum enzyme activity was between pH 7.2 and 7.4. The protease activity from isolate number 25 was stimulated when Fe³⁺, Fe²⁺ and Co²⁺ ions were included in the assay mixtures. In contrast, Zn²⁺, Ni²⁺, Cu²⁺ and Hg²⁺ ions caused inhibition (80-100%) of the protease activity. Metal ions like Ca²⁺ and Mg²⁺ caused only slight inhibition (10-15%). Induced levels of protease production were observed when cultures were grown in minimal media containing either casein or nonfat dried milk powder.

EFFET DES PROCÉDES SUR LA VALEUR NUTRITIVE DES PROTÉINES DE LAIT ÉVAPORÉ. Bégin, A., J. Amiot et J.P. Julien, Département des Sciences et technologie des aliments et Centre de recherche en nutrition, Université Laval, Québec, Québec G1K 7P4.

Dans le travail de recherche nous avons voulu démontrer de quelle façon l'ensemble des traitements industriels utilisés pour la fabrication du lait évaporé peuvent intervenir sur les caractéristiques nutritionnelles des protéines du lait. Des tests nutritionnels effectués sur le rat ont

permis de démontrer que les traitements thermiques de préchauffage, d'évaporation et de stérilisation n'ont pas d'effet sur les coefficients d'efficacité et de digestibilité des protéines du lait entier. La valeur nutritionnelle des protéines de lait dégraissé serait cependant réduite lors du procédé. L'hypothèse d'un effet protecteur des lipides sur les protéines est proposée.

DETERMINATION OF TYRAMINE IN CHEESE BY COMPLEXATION WITH TITANIUM TETRACHLORIDE. Berck, B. and N.A.M. Eskin, Department of Foods and Nutrition, University of Manitoba, Winnipeg, Manitoba R3T 2N2.

The development of aromatic amines during food spoilage is of concern to food scientists in view of their toxicity. This paper reports a specific method for determining tyramine in the presence of other aromatic amines based on complex formation with TiCl₄. Extracts from 5 g samples of four Canadian and fourteen imported cheeses were measured for tyramine levels. Tyrosine interfered only slightly while tryptophan, tryptamine, phenylalanine, phenylethylamine, histidine and histamine did not affect the linearity of the reaction. Of seventeen solvents and solvent systems tested, a mixture of benzene:acetone:water (50:49:1 v/v) gave the best recoveries (97-100%) for tyramine from fortified cheese extracts. Mild cheddar was consistently lower in tyramine levels compared to medium or old cheddar. Cheddar cheese aged for 18 mo had the same tyramine levels as cheese aged for 6 mo, suggesting that a plateau may be reached.

DETERMINATION OF THE HEAT CAPACITY OF SOLID FOOD BY DIFFERENTIAL THERMAL ANALYSIS. Bourgois, J. and M. LeMaguer, Department of Food Science, University of Alberta, Edmonton, Alberta T6G 2P5.

The heat capacity of some solids encountered in food is determined over the temperature range -50°C to +60°C by differential thermal analysis using a Dupont 900 differential thermal analyzer and the attached calorimeter cell.

The method permits a continuous determination of the heat capacity over a wide range of temperature from a single experiment.

The values of the heat capacity are given as a polynomial function of the temperature together with the maximum error and the average error over the investigated temperature range.

ATLANTIC COD PEPSIN CHARACTERIZATION AND USE AS A RENNET SUBSTITUTE. Brewer, P., N. Helbig and N.F. Haard, Department of Biochemistry, Memorial University of Newfoundland, St. John's, Newfoundland A1B 3X9.

Pepsinogen was isolated from the stomach mucosa of Atlantic cod and purified. Kinetic and thermodynamic parameters for catalysis of hemoglobin hydrolysis were determined for the activated zymogen (ACP). ACP had a relatively low Ea for hydrolytic activity and poor thermal stability. Cheddar cheese prepared with ACP as a clotting enzyme was acceptable. ACP clots milk more efficiently than porcine pepsin or chymosin at low temperatures. ACP is inactivated above 35°C, thus minimizing excessive proteolysis during aging of the cheese. Isoelectric focusing and amino acid analyses indicate a similar pattern of proteolysis during aging of ACP and chymosin cheeses. ACP cheese did not develop a strong cheddar flavour, and more fat and protein was lost to the whey than with cheese prepared with chymosin. The data indicate ACP may be a useful milk clotting enzyme for preparation of certain types of cheese.

PERMEABILIZATION OF YEAST CELLS FOR LACTOSE HYDROLYSIS IN DAIRY PRODUCTS. Brodsky, J.A. and E.S. Humbert, Department of Dairy and Food Science, University of Saskatchewan, Saskatoon, Saskatchewan S7N 0W0 and J.W.D. Groot Wassink, National Research Council, Saskatoon, Saskatchewan S7N 0W9.

We are investigating whether nonviable whole yeast cells with improved levels of lactase can be used directly in dairy products. Such a system would enhance industrial application of lactose hydrolysis, considering the reduction in enzyme costs as compared to soluble enzyme preparations. In addition, a simple fermentation and recovery process may allow dairy companies to produce lactase for in-house use.

As an important phase of this work we have developed a simple procedure to permeabilize fresh yeast cells, thus rendering the intracellularly located lactase freely accessible to the substrate lactose. The procedure involves incubation of up to 100 g/L of cells at 50°C for 2-4 h in phosphate buffer (0.1 M, pH 7.5). The efficiency of

permeabilization was strongly dependent on the incubation conditions. After this treatment, as much as 90% of the original lactase activity remained and was accessible, and more than 99.99% of the cells were nonviable.

THE EFFECT OF FEEDING "PROTEC" (A RAPESEED-BASED PROTECTED LIPID FEED SUPPLEMENT) ON MILK QUALITY. Cadden, A.M., P. Jelen and A. Urquhart, Department of Food Science, University of Alberta, Edmonton, Alberta T6G 2P5.

Eight Holstein dairy cows were fed "Protec" at levels of 0, 3, 6 and 9% of the grain for 3 week intervals following a double 4 x 4 Latin square design. Neither the flavour nor the storage stability of the milk and butter produced was affected by feeding the "Protec." Iodine numbers increased from 40 ± 3 to 46 ± 2 with increasing levels of "Protec," indicating a slight increase in the proportion of unsaturated fatty acids. Raw milk from cows fed the highest levels of "Protec" was less susceptible to hydrolytic rancidity induced by blending for 60 s at 37°C as shown by lower ADV measurements and sensory triangle tests.

COMMUNICATING AS A FOOD SCIENTIST - OPEN THE DOORS. Campbell, S.A. and J. Vanderstoep, Department of Food Science, University of British Columbia, Vancouver, British Columbia V6T 2A2.

Misinformation about food issues and the lack of reliable information have resulted in a certain degree of mistrust of processed foods and the food industry. Several surveys of consumer attitudes show the exaggerated perception of the risk involved with the consumption of processed foods, particularly those containing additives. What can we, as food scientists, do about this problem? This poster session will offer guidelines to "opening the doors" in the following areas: (1) The Media - establishing contacts and handling interviews with the press; (2) The Community - informal talks, information centres; (3) The Company - newsletters, bulletin boards, tours; (4) Neighbours - answering questions in nontechnical terms; (5) Individual Action - responding to inaccurate information; and (6) CIFST - current and potential efforts. Current research as to why this problem exists will also be covered.

CONVECTION OVENS STUDY: TIME AND ENERGY CONSUMPTION. Chan, N., Food Advisory Division, Agriculture Canada, Ottawa, Ontario K1A 0C5.

The time and energy consumption of two types of convection ovens were measured and compared to those of conventional ovens. Cooking with a convection range decreased total cooking time by 14% while cooking with a portable convection oven increased it by 8%. Little difference was found between the total energy consumption of the conventional and convection range ovens. A reduction of 40% in energy consumption, however, was achieved by cooking with the portable convection oven. It was concluded that the convection range tested in this study saved time but not energy, while the reverse was observed with the portable convection oven.

REMOVAL OF PHYTIC ACID IN RAPESEED BY ACYLATING AGENTS. Cho, Y-S. and L.U. Thompson, Department of Nutritional Sciences, Faculty of Medicine, University of Toronto, Toronto, Ontario M5S 1A8.

To prepare rapeseed protein isolates with low phytic acid, the extraction and precipitation of protein, phytate and mineral in the presence of varying levels of acylating agents at pH 8.5 were studied. At highest degree of acylation, single extraction of rapeseed resulted in up to 45% increase in nitrogen and 91% decrease in phytic acid extractability. Solubilization of phytic acid was increased in the second extraction. Acylation lowered the isoelectric pH of the protein to pH 3. Free and bound mineral concentration suggests that protein-calcium-phytate complex is formed at lower degree of acylation. At higher degree, calcium-phytate is the predominant form. Changes in protein charges brought about by acylation prevented protein-phytate interaction. Results suggest an alternate method of preparing low phytate protein isolate of good functional properties.

THE STABILITY OF VITAMIN A IN FORTIFIED MILKS. Chung, I. and H. Jackson, Alberta Dairywomen's Association Research Unit, Department of Food Science, University of Alberta, Edmonton, Alberta T6G 2P5.

The content and stability of vitamin A in fortified fluid milks were assessed. Destruction of the vitamin by pasteurization and ultra high temperature (UHT) treatment is minimal. The vitamin remained relatively stable up until and beyond the coded pull dates of the pasteurized (12 days) and UHT milk products (3 mo), stored at 4°C and 20°C, respectively. At 35°C, a 10% decrease in the vitamin content was noted in UHT milks after 12 weeks, accompanied by enhanced cooked flavour in the 2% partially skimmed milk samples and pronounced sedimentation in the chocolate flavoured samples.

EXAMINATION OF NITROGENOUS CONSTITUENTS OF BREWERS SPENT GRAIN. Crowe, N.L. and B.E. Baker, Department of Agricultural Chemistry and Physics, Macdonald Campus of McGill University, Ste. Anne de Bellevue, Québec H9X 1C0.

The aim of this study is to develop methods for the isolation of protein from Brewers spent grain (BSG) for use in foods. The BSG was sized and the resultant fractions were analyzed. The nitrogen content increased as the particle size decreased. The products were extracted with various solvents (water, NaCl, ethanol, acetic acid and NaOH) and the protein fraction isolated. The amino acid compositions of the protein preparations were quite similar; the hexosamines and nucleic acid contents of the proteins have also been determined.

SENSORY AND TEXTURAL PROPERTIES OF SAUSAGE EXTENDED WITH PLANT PROTEIN FIBRES. Delaquis, P.J. and M.B. McConnell, Department of Food Science, University of Manitoba, Winnipeg, Manitoba R3T 2N2.

Protein micellization is a new method for the recovery of proteins from vegetable sources. The isolates obtained (96% protein on a dry weight basis) have functional properties which make them attractive as extenders in comminuted meat systems. In particular, these concentrates can be extruded into fibres of any desired size and resilience which may be used as true meat analogs. Fibres were produced from field pea protein (*Pisum sativum*) and used to extend fresh pork sausage at levels of 10, 20, 30 and 40% on a whole weight basis. The effect of these additions on the textural and sensory qualities of the product were studied. Warner-Bratzler shear and compression values were measured using the OTMS and compared to firmness plus chewiness scores obtained by a sensory panel.

IMPROVING THE NUTRITIVE VALUE OF RAPESEED PROTEINS BY SOLUBILITY DIFFERENCES OF FRACTIONS, HYDROLYSIS AND ULTRAFILTRATION PROCESSES. Delisle, J., M. Lacroix, J. Amiot and G.J. Brisson, Centre de recherche en nutrition, Département de sciences et technologie des aliments and Département de zootechnie, Université Laval, Ste-Foy, Québec G1K 7P4.

The digestibility of rapeseed concentrate protein and of its 2S and 12S fractions may be increased from 81-89% by water solubilization followed by precipitation of soluble proteins by addition of ammonium sulphate. However, these treatments decrease the efficiency of protein conversion by 10%. The nutritional properties of rapeseed meal proteins may also be improved by prehydrolysis (pepsin and trypsin) and ultrafiltration which permit isolation of sub-products of molecular weight lower than 5,000. Nutritional experiments on these protein sources have shown values of NPR comparable to that of casein.

STATUS OF VOLUNTARY QUALITY CONTROL SYSTEMS IN USA MEAT AND POULTRY PROCESSING PLANTS. Dennis, W.F., Director, Processed Products Inspection Division, Meat and Poultry Inspection Technical Services, United States Department of Agriculture, Washington, D.C. 20250.

Voluntary quality control systems to demonstrate meat and poultry plants' compliance with federal regulations for processed products have been used since September 15, 1980. The number of plants approved and implemented, and a profile of these systems is discussed.

The regulatory inspector's role and the plan of inspection are outlined. Regulatory philosophy is impacted by statistical quality control principles. A review of USDA's quality control regulations is presented. The elements of an approved quality control system are presented in a broad overview. The small proprietor is encouraged to participate. A formal quality control department in the small plant is not required.

ALKANOL AMMONIA EXTRACTION OF RAPESEED MEAL. Diosady, L.L., M.R. Halfani, C.R. Phillips and L.J. Rubin, Depart-

ment of Chemical Engineering and Applied Chemistry, University of Toronto, Toronto, Ontario M5S 1A4.

Although the glucosinolate content of Canola meal is substantially lower than that of earlier varieties, the residual glucosinolate levels must be decreased by at least a further order of magnitude before the meal may be acceptable for incorporation into food products.

Canola meal was extracted with lower aliphatic alcohols containing dissolved ammonia. Methanol containing 10% or more dissolved ammonia reduced the glucosinolate content of the meal from 1.5 to less than 0.2 mg/g. Results with ethanol were similar. Propanol and butanol were only partially effective in removing glucosinolates, but were somewhat more effective in the presence of water.

The effect of methanol concentration, moisture content, solvent: seed ratio, and contact time were investigated.

Methanol ammonia systems promise to be viable in removing and destroying all residual glucosinolates in the meal to the level of detectability attainable by the Youngs and Wetter spectrophotometric method.

DETECTION DE LA MAMMITE PAR LE DOSAGE DE LA CATALASE. Dubois, G., G. Normil, M. Gagnon, G. Roy et R. Charbonneau, Centre de recherches en sciences appliquées à l'alimentation (CRESALA^R), Université du Québec, Montréal, Québec H3C 3T8.

Plusieurs auteurs mentionnent qu'il peut exister une relation Leucocytes-Catalase-Mammite. L'activité catalasique du lait a donc été déterminée après la mise au point d'une méthode et en utilisant un Catalasimètre^R. Des analyses statistiques portant sur plusieurs centaines de données ont montré qu'il existait une corrélation très forte entre le nombre de leucocytes reflétant l'état de santé du pis et le taux de catalase présente dans le lait. Avec cette méthode de mesure automatisée simple, rapide et précise, nous avons pu détecter la mammite à des degrés divers *in situ* au niveau du pis de la vache et dans chacun des quartiers.

REPORT ON THE INTERNATIONAL DAIRY FEDERATION. Emmons, D.B., Food Research Institute, Research Branch, Agriculture Canada, Ottawa, Ontario K1A 0C6 and L. Rodgers, Secretary-Treasurer, FIL-IDF Canada, c/o Animal Products Division, Agriculture Canada, Ottawa, Ontario K1A 0C5.

The major event in 1982 is the XXI International Dairy Congress, Moscow, July 12-16. Participating Canadians will be: Mr. Savage as President of IDF, Mr. Hurd, Session Chairman, and six invited speakers. Important meetings were the Seminar on Recombined Milk and Milk Products (Singapore, October 1980), Seminar on Dairy Education (Rome, May 1980), Seminar on Dairy Ingredients in the Food Industry (Luxembourg, May 1981) and Symposium on Bacteriological Quality of Raw Milk (Kiel, September 1981). Planned meetings are: Seminar on Cow of the Future (Warsaw, August 1982), Workshop on Computer Application in Milk Transport (Toronto, September 1983), Symposium on Role of Milk Proteins in Human Nutrition (Kiel, March 1983), Second Seminar on Dairy Effluents (Killamey, April 1983), Symposium on Physico-Chemical Aspects of Dried Protein-Rich Milk Products (Denmark, May 1983) and a Seminar on Fermented Milks (France, 1984). IDF continues to publish about one dozen documents each year and various standards and methods of analysis, e.g., a revised Monograph on UHT Milk (available from the Secretary).

DETECTION OF GLUCOSE OXIDATION PRODUCTS IN CHILLED FRESH MEATS UNDERGOING SPOILAGE. Farber, J.M. and E.S. Idziak, Macdonald Campus of McGill University, 21, 111 Lakeshore Road, Ste. Anne de Bellevue, Québec H9X 1C0.

The fate of nutrients during storage of longissimus dorsi muscle at 4°C was examined. Glucose concentrations in meat were shown to decrease with time concomitant with an approximately fourfold increase in the activity of glucose dehydrogenase. Using an enzyme assay, gluconate concentrations in meat were determined and shown to increase from 2.3-39.8 µg/g upon storage of the meat from day 0 to day 6. At day 12, gluconate concentrations had decreased to 10.6 µg/g. Dark firm dry meat, which contains little or no glucose, did not exhibit the same rise and fall in gluconate concentration. Thin layer chromatographic analysis confirmed the presence of 2-keto-gluconate in 6 and 12 day old longissimus dorsi muscle that had been stored at 4°C. It appears that glucose, at 4°C, is being converted to gluconate and/or 2-keto-gluconate extracellularly, by one of the main meat spoilage organisms, most likely the *Pseudomonas*.

A COMPOSITE REFERENCE STANDARD FOR THE IDENTIFICATION OF POTATO GLYCOALKALOIDS. Filadelfi, M.A., School of Food Science, Macdonald Campus of McGill University, Ste. Anne de Bellevue, Québec H9X 1C0 and A. Zitnak, Department of Horticultural Science, University of Guelph, Guelph, Ontario N1G 2W1.

A simple reference standard had to be developed to facilitate positive identification of all degradation products of enzymatic hydrolysis in various potato tissue homogenates. This very simple reference standard was comprised of a mixture of all eight glycoalkaloid substances likely to occur in potato plant extracts and was obtained by simply terminating the stepwise degradation by mild acid hydrolysis (95% EtOH containing 1% HCl) of α -solanine and α -chaconine for 45 min. The products of this hydrolysis were combined and resolved during a single TLC run using the developing solvent of Osman *et al.* (1978). The resolution of the eight substances in the order of their solubility (R_f values) occurred as follows: α -S (.26), α -Ch (.34), β_2 -S (.40), β_1 -Ch (.44), β_2 -Ch (.55), γ -S (.67), γ -Ch (.71) and SD (.97).

TASTE THRESHOLDS OF POTATO GLYCOALKALOID BITTERNESS. Filadelfi, M.A., School of Food Science, Macdonald Campus of McGill University, Ste. Anne de Bellevue, Québec H9X 1C0 and A. Zitnak, Department of Horticultural Science, University of Guelph, Guelph, Ontario N1G 2W1.

Glycoalkaloids are known to contribute to the bitter off-flavour of potato tubers. Taste differences and threshold concentrations were determined by tasting weak acidic solutions of α -solanine, α -chaconine and β_2 -chaconine in 0.02% lactic acid. These taste tests revealed two distinct taste perceptions; the first was a bitter sensation, coincidental with or followed by a peppery burning sensation. Detection thresholds for bitterness were 60 ppm for α -solanine and 15 ppm for both α -chaconine and β_2 -chaconine. The burning sensation was noticed at 120 ppm for α -solanine and 30 ppm for both chaconines. In general, α -solanine was less bitter than either chaconine by a factor of four. From these observations it seems certain that the two chaconines are the major contributors to potato tuber bitterness.

THE MECHANICAL PROPERTIES OF SCALLOP MUSCLE. Findlay, C.J. and D.W. Stanley, Department of Food Science, University of Guelph, Guelph, Ontario N1G 2W1.

The hardness of scallop muscle, as measured by Instron compression, increases as a function of heating. Heating in boiling water results in a linear response with respect to time. Equilibration in circulating water to temperatures of 25, 40, 50, 55, 60, 65, 70, 75 and 80°C gives a step function that is linear below 60°C and above 65°C. The first linear change reflects the increase in hardness due to dehydration. Room temperature dehydration produced a similar linear increase in hardness. The second linear portion has a greater slope, probably due to thermal shrinkage of connective tissue as well as dehydration. The transition reflects the denaturation of myofibrillar proteins and the average hardness increases by 4.38 N/scallop.

THE MICROSTRUCTURAL SCORING OF MUSCLE TEXTURE. Findlay, C.J. and D.W. Stanley, Department of Food Science, University of Guelph, Guelph, Ontario N1G 2W1.

Food texture is a consequence of microstructure. Quantitative evaluation of microstructure should relate directly to texture measurement. Scallop adductor muscle is an excellent model system to study the behaviour of myofibrillar protein. Previously frozen samples were equilibrated in a circulating water bath to temperatures of 25, 40, 50, 55, 60, 65, 70, 75 and 80°C. Each sample was blind coded and examined by SEM to determine a percentage of irregular fibres. This figure was about 30% for uncooked muscle. Samples below 50°C gave damage results under 45%, while those over 65°C were above 60%. The response parallels the Instron compression step function that reflects denaturation of myofibrillar proteins between 60 and 65°C. Linear regression of damage vs. hardness gave an R^2 of 0.86 at $P = .004$.

FAST ATOM BOMBARDMENT MASS SPECTROMETRY OF CHLOROPHYLLS. Fisher, R.W. and H. Daun, Department of Food Science, Cook College, Rutgers University, New Brunswick, New Jersey 08903.

Naturally occurring pigments, such as the chlorophylls, are thermally labile, nonvolatile compounds. These pigments have not been previously identified without chemical alteration or the formation of derivatives of these compounds. The development of fast atom bombardment (FAB)

mass spectroscopy has enabled researchers to obtain molecular ions and fragment ions directly from the unaltered pigments. The FAB mass spectra of the natural colourants chlorophyll a and b will be presented.

EFFECT OF STORAGE ON BITTERNESS DEVELOPMENT, PROTEOLYSIS AND VISCOSITY IN UHT MILK. Froehlich, D.A. and R.C. McKellar, Food Research Institute, Agriculture Canada, Ottawa, Ontario K1A 0C6.

The effect of storage on bitterness development, proteolysis and viscosity of ultra high temperature (UHT) milk was examined. UHT milk from four producers (two direct and two indirect sterilization methods) were kept at 25°C and evaluated every 2 weeks during a 20 week storage period. Bitterness, as evaluated by a thirteen member trained panel, using an unstructured 15 cm scale for intensity of bitterness, showed a progressive increase over time. Proteolysis, measured as the increase in trichloroacetic acid soluble free amino groups, and viscosity also increased during storage. UHT milk sterilized by the direct method was particularly susceptible to spoilage due to proteolytic enzymes and coagulation. The correlation between perceived bitterness and proteolysis was good, indicating the possibility in predicting UHT milk shelf life from proteolysis measurements.

EFFICACITE DE HUIT DESINFECTANTS SUR DIFFERENTS TYPES DE SURFACE. Gélinas, P. and J. Goulet, Département de sciences et technologie des aliments, Université Laval, Québec, Québec G1K 7P4.

A partir de la méthode de dilution d'emploi de l'AOAC (1980), nous avons étudié l'influence de trois types de surfaces communément rencontrés en industrie alimentaire sur l'activité désinfectante de huit produits commerciaux. Après avoir inoculé des anneaux d'acier inoxydable, de polypropylène et d'aluminium au moyen d'une suspension de *Pseudomonas aeruginosa* ATCC 15442, ces derniers furent séchés et désinfectés par immersion dans chacune des solutions sous étude. Pour la grande majorité des produits testés, des concentrations dix fois supérieures à celles efficaces sur l'acier étaient requises pour désinfecter le polypropylène et l'aluminium. L'examen au microscope électronique à balayage démontre que l'adhésion des bactéries serait étroitement reliée à la nature des surfaces.

THE MANIPULATION OF THE THERMAL GELATION PROPERTIES OF VEGETABLE PROTEIN ISOLATES USING CONDITIONS OF pH AND NaCl CONCENTRATION. Grealy, J.M., T.J. Maurice and C.D. Myers, General Foods, 520 William Street, Cobourg, Ontario K9A 4L4.

The thermal gelation properties of vegetable protein isolates, produced via a novel process, can be manipulated by altering the conditions of pH and NaCl concentration. Isolates from sources such as fababean, soybean and rapeseed can be used to achieve thermal gels similar to those produced with egg albumen.

ROLE OF INDUSTRIAL GASES IN THE FOOD INDUSTRY. Hayek, J., Canadian Liquid Air Ltd., 1155 Sherbrooke Street West, Montréal, Québec H3A 1H8.

Applications of gases in the food industry have been in use for some 15 years. Gaseous or liquid N₂ and CO₂ are used worldwide and in Canada usage volume currently exceeds 100,000 tons/year. Industrial gases are introduced in many food sectors where their neutral and cold properties are needed most. Applications such as freezing, chilling, inerting and sparging use gases to prevent deterioration in many foods. Trends for the future in the use of industrial gases and cryogenics will be discussed.

A NEW CONTINUOUS ANION EXCHANGE PROCESS FOR DESALTING CHEESE WHEY. Helbig, N.B., K. Eugster and S. Nakai, Department of Food Science, University of British Columbia, Vancouver, British Columbia V6T 2A2.

An anion exchange resin was packed in a loop of cotton knit tubing which was cycled continuously around rollers. During cycling, the resin belt was dipped successively in tanks containing cottage cheese whey and 1 N KOH. The whey thus neutralized had a pleasant, mildly sweet taste suitable as an ingredient for food processing. This new system is simpler in construction than the fluidized bed system and also reduced the resin disintegration since no resin pumping is required. The system is also easily adaptable to small or large processing size. Factors affecting the desalting efficiency have been investigated.

THE ENZYMIC RELEASE OF FATTY ACIDS FROM PHOSPHATIDYLCHOLINE IN PEAS. Henderson, H.M., J. Kanhai and N.A.M. Eskin, Department of Food Science, University of Manitoba, Winnipeg, Manitoba R3T 2N2.

Deterioration in the flavour of fresh or unblanched frozen peas during postharvest storage may be partly due to the activity of lipid degrading enzymes. While the enzymes lipoxygenase, lipase and phospholipase D have been demonstrated in peas by other workers, this study describes the enzymic release of fatty acids from phosphatidylcholine, suggesting the presence in peas of phospholipase A and/or B activities. The biochemical properties of this enzymic activity will be described. The objective is a greater understanding of the role of lipid degrading enzymes in the postharvest degradation of endogenous lipids in peas.

STORAGE OF JERUSALEM ARTICHOKE TUBERS FOR HIGH FRUCTOSE SYRUP PRODUCTION. Hoehn, E., R.W. Kolesar and J.W. Rogers, Department of Food Science, University of Manitoba, Winnipeg, Manitoba R3T 2N2.

Currently we are evaluating the potential of Jerusalem artichoke as a source of high fructose syrup. Manufacturing based on a year round rather than seasonal operation appears more viable, but would require year round storage of tubers. Tubers were submitted to cold, frozen and dehydrated storage. Total sugar loss, change of fructose/glucose ratio and spoilage were monitored. Changes observed in cold stored tubers included a slight decrease of total sugars, a decrease of the fructose/glucose ratio and substantial spoilage (50%) occurring after 8 weeks in storage. Treatment of cold stored tubers with mold inhibitor reduced spoilage, and no spoilage occurred in frozen or dehydrated samples. Since none of the treatments affected extractability of the sugars from the tubers, it may be feasible to use frozen storage for winter and dehydrated storage for balance of year processing.

MICROWAVE HEATING OR MOISTURE ADJUSTMENT TO ELIMINATE NEMATOSPORA FROM MUSTARD SEED. Holley, R.A., Food Research Institute and G.E. Timbers, Engineering and Statistical Research Institute, Research Branch, Agriculture Canada, Ottawa, Ontario K1A 0C6.

In 1979, 50% of the North American crop of *Brassica juncea* was highly contaminated with *Nematospora*. A continuous flow microwave system was used successfully to destroy the yeast without affecting the desirable bitter principle of mustard. At the natural moisture level of 6.8%, a temperature of 87.2°C was needed to kill the yeast, whereas in seed adjusted to 9.74% moisture, a temperature of 70.8°C was adequate. Coincidentally it was found that sublethally heated yeast died off in the moisture amended seed during storage. Simple adjustment of seed moisture to >10% yielded *Nematospora*-free seed if stored 13 days at 37°C or 37 days at 23°C. At 4°C and 14.9% moisture there was no effect on *Nematospora* viability up to 77 days.

EVALUATION OF METAL FOOD CANS - A CURRENT PERSPECTIVE. Hotchner, S.J., Manager, Evaluation & Specifications, Metal Container Research, American Can Company, 433 N. Northwest Highway, Barrington, Illinois 60010.

Both the can manufacturer and the food packer need accurate knowledge of the effect foods have on the can, and vice versa. An understanding of food can performance is achieved through blending the recognized scientific disciplines of statistics, food science, sensory testing, analytical chemistry and electrochemistry with metal can technologies. The resulting empirical evaluation approach is described, with examples of how all these disciplines are jointly applied to the current challenges arising from the availability of new materials and alternate can manufacturing processes.

IN-PLANT RECYCLING OF FOOD PROCESS WATERS. Hydamaka, A.W., R.A. Gallop and J. Yau, Department of Food Science, University of Manitoba, Winnipeg, Manitoba R3T 2N2.

The food industry uses large quantities of potable water, usually inefficiently, to create corresponding effluent/environmental problems. By contrast, the authors have shown that appropriate grades of water can be efficiently used at each food processing operation, under excellent quality control of both phases, for extended periods. Small in-plant purifier modules (especially using activated carbon) can permit rapid purification and intensive recycling of major process waters, such as in vegetable, fish and poultry processing. Major possibilities exist for

improvements in quality and yields of products, using these techniques, which will be described in this paper.

PROCESSING AND FERMENTATION OF AFRICAN LOCUST BEANS, *PARKIA FILICOIDEA* WELW. Ikenebomeh, M.J. and R. Kok, Department of Microbiology, Macdonald Campus of McGill University, Ste. Anne de Bellevue, Québec H9X 1C0.

African locust beans, *Parkia filicoidea* Welw., were processed and fermented to the traditional West African food, dawadawa. This food is generally eaten as a condiment and is a cheap source of protein. It is also a good source of lysine. The fermentation was carried out at 37°C in static fermentors. The mass balance of the fermentation was studied. It was found that 1.0 kg of unprocessed beans (8% water by weight) yielded 1.3 kg of raw substrate (62% water by weight) which in turn was converted to 1.2 kg of final product (65% water by weight). The loss of solids during processing was due to the removal of the pulp adhering to the beans and of the testa; the loss of solids during fermentation was presumably due to microbial utilization of the substrate for energy.

ORIGIN OF VOID SPACES IN FERMENTED MILK PRODUCTS. Kalab, M., R.P. Sinha, P. Allan-Wojtas and B. Phipps-Todd, Food Research Institute, Research Branch, Agriculture Canada, Ottawa, Ontario K1A 0C6.

Void spaces found around lactic bacteria in fermented milk products have been attributed either to differences between the shrinkage of the bacteria and that of the surrounding protein network during fixation and dehydration of the sample, or to the action of proteolytic enzymes produced by the bacteria. To determine the cause of the voids, yoghurts were made with viable lactobacilli (*L. bulgaricus*) from reconstituted nonfat dry milk (20% total solids) in which streptococci (10^{12} cells/mL) killed by heating to 60°C for 30 min were dispersed. Yoghurts containing dead lactobacilli were made with viable streptococci (*S. thermophilus*). Void spaces were found by scanning electron microscopy only around viable bacteria, whereas dead bacteria were tightly encompassed with casein micelles in the yoghurts. This indicates that the void spaces were formed by enzymatic digestion of protein in the immediate vicinity of the viable bacteria.

THE EFFECT OF ANTIBROWNING AGENTS ON THE EXTRACTION OF PROTEIN FROM HYBRID POPLAR FOLIAGE. Kamel, F.R.M. and I. Altosaar, Food and Nutrition Program, Department of Biochemistry, University of Ottawa, Ottawa, Ontario K1N 9B4.

The possibility of producing a food grade protein concentrate from forest foliage was investigated. The growth rate of poplar trees is remarkably high and represents a large amount of potential biomass for the production of leaf protein concentrate. Methods were developed for isolating poplar proteins with minimal interference from phenolic compounds. Polyvinylpyrrolidone (0.2%) and sodium sulphite (1%) added to the extraction buffer allowed about 30% increase of crude protein concentrate with minimal colouring. The total protein content of poplar leaves is about 30% of dry weight. Also, poplar leaves contain high amounts of phenolic compounds (141 mg/g dry weight). Field studies compared moisture, protein and phenolic contents of poplar with those of alfalfa, tobacco and rapeseed foliage.

UTILIZATION OF RESIN NEUTRALIZED WHEY IN BREAD, CAKE AND BEVERAGES. Keshavarz, E., N.B. Helbig and S. Nakai, Department of Food Science, University of British Columbia, Vancouver, British Columbia V6T 2A2.

The salty taste of cottage cheese whey was eliminated by anion exchange, which removed 80% of the chlorides with a slight loss of calcium and riboflavin. Blends of up to 60% resin neutralized whey and skim milk powder (SMP) showed no taste difference from SMP alone. Lactose treatment further improved the flavour. For bread, the best loaf volume was obtained when SMP was completely replaced by neutralized whey heated at 100°C for 20 min. For cake, the neutralized whey could completely replace SMP. This whey was also added up to 10% and 8% solids levels to tomato and vegetable juices, respectively, without detectable flavour difference.

EFFECT OF STORAGE TIME AND TEMPERATURE ON SOME PROPERTIES OF COMMERCIAL UHT PROCESSED MILK. Keya, E., P. Jelen and C. Foster, Department of Food Science, University of Alberta, Edmonton, Alberta T6G 2N2 and Palm Dairies Limited, Edmonton, Alberta.

Milk obtained from industrial processing line (VTIS) was stored at 10, 24, 30 and 40°C for up to 14 weeks. Measurements of lightness, total colour change, sediment and hydroxymethylfurfural indicated significant effects of storage at 40°C and, to a lesser degree, at 30°C. Changes at 24°C were not significant, except for sedimentation and total chromaticity, where values comparable to 30°C storage were obtained. Determinations of total glucose, lactose and whey protein nitrogen did not change except at 40°C after 14 weeks. Products stored at 40°C would not be acceptable for consumers due to colour and flavour deterioration.

CAUSES OF ABNORMAL STARTER CULTURE DEVELOPMENT IN YOGHURT FORMULATED WITH COTTAGE CHEESE WHEY. Kinder, M-A. and E. Jackson, Department of Food Science, University of Alberta, Edmonton, Alberta T6G 2P5.

Attempts to utilize neutralized cottage cheese whey (NW) directly as a reconstituent for nonfat dry milk (NFDM) in yoghurt formulations have resulted in products inferior to controls using water (final pH, 4.3-4.5; penetrometer texture, 70-76.4 g force). NW yoghurts showed higher final pH values (4.85-5.0) and poor textures (12.1-14.7 g force) and required extended fermentation times (7-8 h). This occurred irrespective of the neutralizing agent used. Abnormalities in starter culture development were observed which, following model trials on the primary effects of added lactose, ultrafiltration (UF) whey protein concentrates and UF permeates to control formulations, were attributed to increased levels of whey salts. Specifics of the effects of individual whey salts on the development of the *Streptococcus thermophilus* and *Lactobacillus bulgaricus* components of Hansens CH2 starter culture will be discussed.

THE PRODUCTION OF INSECTS FOR HUMAN FOOD. Kok, R., Department of Agricultural Engineering, Macdonald Campus of McGill University, Ste. Anne de Bellevue, Québec H9X 1C0.

In this paper are discussed some aspects of a promising new sector of agriculture, the use of insects to convert low quality plant materials such as cellulose to structured and highly palatable animal flesh. The paper was written with the future needs of spaceship crews in mind. An insect farm, based on the use of packed beds for organism incubation, growth and reproduction, is discussed and design parameters are determined. The drugstore beetle (*Stegobium paniceum*) is investigated as an initially attractive organism. Several system configurations (batch, semicontinuous and continuous) are explored, and the advantages and disadvantages of a variety of growth reactors (batch, plug flow and backmix) are examined. The design of a reproduction facility and the problems attendant to the maintenance of population synchrony are also considered. Calculations are presented for a facility to supply the animal protein for one hundred people. From the results, it is evident that the concept is feasible.

A MATHEMATICAL MODEL OF THE CONTROLLED ATMOSPHERE STORAGE OF APPLES USING THE MARCELLIN SYSTEM. Kok, R. and G.S.V. Raghavan, Department of Agricultural Engineering, Macdonald Campus of McGill University, Ste. Anne de Bellevue, Québec H9X 1C0.

In the Marcellin system, the product's metabolism is used to absorb oxygen and generate carbon dioxide in a storage unit. The gas composition is controlled by allowing the various gases to diffuse to and from the atmosphere through a membrane. In this study were investigated the effects of a variety of factors on both the transient and steady state behaviour of the gas phase composition in a Marcellin equipped storage unit by means of a mathematical model. The independent variables studied included: product (apples) metabolic rate function, chamber loading and membrane area, thickness and permeabilities.

A NEW ENZYMATIC METHOD FOR THE DETERMINATION OF VITAMIN C (ASCORBIC ACID) IN FOODSTUFFS. Lee, K., G. Henniger and H.O. Boutler, Boehringer Mannheim Canada, 11450 Côte de Liesse, Dorval, Québec H9P 1A9.

The tetrazolium salt MTT [3,(4,5-dimethylthiazolyl)-2,5-diphenyltetrazolium bromide] was found to be reduced to a formazan by ascorbate in the presence of PMS (5-Methylphenazinium methyl sulphate) in a citrate buffer at pH 3.5. By the use of a sample blank in which the ascorbate had been enzymatically removed by ascorbic acid oxidase, the ascorbate content in the sample could be specifically quantitated by means of the absorbance of the MTT-formazan at 578 nm without any interferences by sugars or sugar alcohols usually found in foodstuffs,

up to a quantity of about 30 mg each per cuvette. Dehydroascorbate could also be assayed by this method after being reduced by homocystein.

THE EFFECTS OF SURFACTANTS ON THE CRYSTALLIZATION BEHAVIOUR OF HYDROGENATED CANOLA OIL. Lee, S.F. and J.M. deMan, Department of Food Science, University of Guelph, Guelph, Ontario N1G 2W1.

The effects of several surfactants on the crystallization behaviour of hydrogenated Canola oil were examined. Some surfactants were found to control crystal growth while others had little effect. DSC results showed these crystal inhibitors were able to prevent polymorphic transitions of the fat crystals. They appear to prevent the repacking of glyceride molecules into a larger crystal lattice through steric hindrance. The addition of surfactants did little to alter the solid fat content of the initial fat but in some cases were able to depress the dropping point.

ISOLATION AND STRUCTURAL STUDIES OF THE ACIDIC POLYSACCHARIDE FROM *PSEUDOMONAS FRAGI* ATCC 4973. Lee Wing, P., G.G.S. Dutton¹ and B.J. Skura, Department of Food Science, University of British Columbia, Vancouver, British Columbia V6T 2A2 and ¹Department of Chemistry, University of British Columbia, Vancouver, British Columbia V6T 1Y6.

During the microbial spoilage of meat surfaces by *Pseudomonas fragi*, a glycocalyx material is produced by the microorganism that aids in its adhesion to the substrate. *P. fragi* ATCC 4973 was inoculated onto trypticase soy agar plates and incubated at 4°C for 24 h. The capsular microorganisms were harvested, treated with a 1% phenol solution and ultracentrifuged. The supernatant was subjected to both ethanol and CETAVLON precipitation, and the resulting precipitate was centrifuged to isolate the acidic polysaccharide. Chemical and physical analyses, utilized to determine the polysaccharide structure, included chromatography, methylation analysis, GC-MS and NMR spectroscopy. An amino sugar and uronic acid residue are present in the repeating unit of the acidic polysaccharide chain.

QUALITY AND OXIDATIVE CHANGES OF DILL OIL DURING STORAGE. Logie, J.R. and E. Hoehn, Department of Food Science, University of Manitoba, Winnipeg, Manitoba R3T 2N2 and B.B. Chubey, Research Station, Agriculture Canada, Morden, Manitoba R0G 1J0.

Dillweed oil is prone to oxidation during storage resulting in increased d-carvone levels. The objectives of this study were to determine the oxidative pathways leading to the carvone buildup and to investigate the effects of weed contaminants, headspace and storage temperature plus antioxidants, on the rates of oxidation. Gas chromatography and mass spectrometry were used to monitor changes in oil composition, and these methods were complemented with sensory analysis. α -phellandrene proved most labile to singlet oxygen attack and shielded d-limonene from autoxidation until its levels decreased. At least 15% of α -phellandrene was converted to d-carvone, while d-limonene conversion to carvone exceeded 20%. The increases in carvone levels had a more pronounced sensory impact than the corresponding decreases in both α -phellandrene and d-limonene.

CHEMICAL CHARACTERIZATION AND FUNCTIONALITY ASSESSMENT OF OSBORNE FRACTIONS FROM OAT. Ma, C-Y., Food Research Institute, Agriculture Canada, Ottawa, Ontario K1J 0C2.

Osborne solubility fractions, albumin, globulin, prolamine and glutelin, were prepared from sentinel oat groats defatted with hexane. Globulin is the major fraction, constituting about 50% of total soluble proteins. Compared to other cereals, prolamine and glutelin contents, each about 20%, are low in oat. The amino acid compositions of the four fractions are similar to those reported in other cereals. The four fractions showed unique chromatographic and electrophoretic patterns. The functional properties, including solubility, emulsifying, water hydration, fat binding and foaming capacity, were also significantly different among the four fractions.

COMPOSITION AND PROPERTIES OF TWO PROTEIN ISOLATES FROM OAT. Ma, C-Y., Food Research Institute, Agriculture Canada, Ottawa, Ontario K1J 0C2.

Protein isolates were prepared from high protein oat varieties, Hinoat and Sentinel, by two methods: isoelectric precipitation of an alkaline extract, and salt extraction near neutral pH. The yield of

protein was over 60% in the alkaline procedure, and only 30-40% in the salt extraction. Both isolates have over 85% protein with a good balanced amino acid composition. The two isolates were characterized by gel filtration chromatography, SDS gel electrophoresis and isoelectric focusing. Some functional properties of the two isolates were assessed and were found to compare favourably with other plant proteins, suggesting the potential use of the oat isolates as a food ingredient.

THE USE OF *S. LACTIS LONGI* IN THE PRODUCTION OF SOUR CREAM. Macura, D., P.M. Townsley and D.S. Smith, Department of Food Science, University of British Columbia, Vancouver, British Columbia V6T 2A2.

Stabilizers can be used in the manufacture of sour cream to prevent syneresis and to improve texture. 10.5% butterfat milk was inoculated with commercial sour cream culture and *S. lactis longi* (50/50) at a level of 3% v/v. Maximum viscosity before shearing is much higher for the experimental than for the control, which contained sour cream culture plus 0.7% by weight stabilizer blend. The new product has a smooth texture, pleasing mild flavour, and possibly a better shelf life and stability than commercial sour cream.

MICROBIAL BIOCONVERSION OF RUB-AL-TAMAR (DATE SYRUP) WASTES FOR SCP PRODUCTION. Madi, N.S. and J. Liston, Institute for Food Science and Technology, WH-10, College of Ocean and Fishery Sciences, University of Washington, Seattle, Washington 98195.

Two fungi, one of which was identified as *Fusarium* sp., were isolated from rotted cellulosic wastes of date syrup processing. Biodegradability of the wastes by both isolates along with *Trichoderma reesei* QM9123 was studied. *Fusarium* sp. showed high cellulase activity comparable to the leading strain, *T. reesei*. To enhance the bioconversion of the waste, symbiotic fermentations with each of the three fungi and *Saccharomyces cerevisiae* or *Candida utilis* were tested. Significant increase in bioconversion and protein production was achieved. Growth of the fungi throughout the fermentation processes was followed by measuring the biodegradability, cellulase activity, reducing sugars and cell protein production.

THE ESTIMATION OF THERMAL PROCESS TIMES USING THE ARRHENIUS EQUATION. Manji, B.S. and F.R. van de Voort, Department of Food Science, University of Guelph, Guelph, Ontario N1G 2W1.

The thermal death time (TDT) concept originated by Ball and expanded upon by others for the determination of adequate heat processes for food preservation and safety is in direct conflict with the classic arrhenius first order reaction kinetics. Theoretical comparisons were made between the two methods using centre point thermal process parameters which illustrated basic similarities in the results as long as the temperature range covered is minimal. A computer program was written for an HP-85 which was capable of evaluating processing times by either method and tested using *Saccharomyces carlsbergensis* as a test organism by conduction and convection heating. The arrhenius approach is intuitively simpler to grasp and is capable of presenting process data in terms of energy.

SUBMERGED PRODUCTION OF EDIBLE MUSHROOM MYCELIUM. Martin, A.M., Department of Biochemistry, Memorial University of Newfoundland, St. John's, Newfoundland A1B 3X9.

The edible mushroom *Morchella esculenta* has been adapted, for the first time, to growth in peat extracts. Shaker flask fermentations were conducted with acid sphagnum peat hydrolysates in order to evaluate the incidence of different factors on the growth, temperature, retention time, agitation, inoculum ratio, and initial pH and carbohydrate concentration. From the final biomass concentration obtained and the yield of dry mycelium produced per total carbohydrates consumed, it is evident that peat extracts could be explored further in the production of this potentially commercial mushroom.

IMPROVED PROCEDURE FOR EVALUATING RANCIDITY IN FISH IN TERMS OF THE FORMATION OF TBA REACTIVE SUBSTANCES. Martinez, C.R., E. Cervantes and P.J. Ke, Fisheries and Oceans Canada, Fisheries Development Branch, P.O. Box 550, Halifax, Nova Scotia B3J 2S7.

An improved method for determining the degree of rancidity in fish tissues has been developed. The rancidity indicating compounds which

are quantitatively reacted with 2-thiobarbituric acid (TBA) are digested and separated directly from fish samples by a specific distillation, and then estimated by a spectrophotometric measurement at 538 nm. The operational errors, interferences and recovery of volatile carbonyls of this described procedure have been investigated, respectively. The recommended technique has been employed satisfactorily for various fish quality evaluations with the overall deviation of 5% and the detection limit of 0.2 moles of TBA reactive compounds of 10 g of fish tissue.

PREDICTION OF TRANSIENT HEAT TRANSFER IN FOODS PACKAGED IN RETORTABLE POUCHES AND STERILIZED BY THERMAL CONDUCTION. McGinnis, D.S., Engineering and Statistical Research Institute, Research Branch, Agriculture Canada, Central Experimental Farm, Ottawa, Ontario K1A 0C6.

A mathematical model was developed to predict the temperature distribution within a retort pouch packaged food product undergoing thermal sterilization by conduction heating. This modelling tool allows the assessment of different processing strategies on the degradation of harmful bacteria and on the retention of nutrients.

A finite difference computer solution to the transient three dimensional heat transfer problem was obtained by approximating the pouch to a rectangular parallelepiped. The temperature dependence of the foods' thermal properties, the processing conditions and the effects of surface heat transfer phenomena are integral components of the model.

EVALUATION OF ENZYME BLENDS FOR THE PRODUCTION OF HIGH FRUCTOSE SYRUPS FROM JERUSALEM ARTICHOKE TUBERS. McKay, C.J. and E. Hoehn, Department of Food Science, University of Manitoba, Winnipeg, Manitoba R3T 2N2.

High fructose corn syrups are widely used as commercial sweeteners, and their use is predicted to increase further. An alternate source of high fructose syrups, to complement existing sources, is inulin and related fructosans from the tubers of Jerusalem artichoke (*Helianthus tuberosus* L.). A technique developed at the University of Manitoba to process Jerusalem artichoke tubers relies on enzymic hydrolysis of inulin and related fructosans to fructose and glucose. A commercially available invertase and a recently developed commercial inulase from *Aspergillus* sp. were evaluated with regard to their suitability in the above process. Hydrolysis was monitored by chemical assays and gas chromatography to determine the extent and nature of hydrolysis. The use of blends of these enzymes was examined as a function of the degree of polymerization of the substrate, and positive results were obtained.

EVALUATION OF THE CH STRETCH MEASUREMENT FOR THE ESTIMATION OF FAT EMULSIONS USING INFRARED SPECTROSCOPY. Mills, B.L. and F.R. van de Voort, Department of Food Science, University of Guelph, Guelph, Ontario N1G 2W1.

Measurement of infrared absorption by the use of a CH stretch filter, which isolates wavelengths in the order of 3.4-3.5 μm , has been suggested as a replacement for the conventional carbonyl stretch absorption measurement or as an additional measurement for the estimation of fat in aqueous fat emulsions. To determine the merits of this CH stretch measurement, a study was conducted with a series of natural fats selected for their differences in average molecular weight, fatty acid composition and degree of unsaturation. In this study, the use of the CH stretch filter or the C=O stretch filter or the combination thereof, could predict the fat content with equal accuracy if the fat was consistent in average molecular weight and degree of unsaturation. For a fat which varied in its degree of unsaturation, the CH filter measurement could be used in conjunction with the iodine value to produce accurate results. The combination C=O, CH filters and the iodine value produced the most accurate results when the intent was to analyze a variety of fats on a single calibration.

METABOLISM OF p,p'-DDE (2,2-BIS(p-CHLOROPHENYL)1,1-DICHLOROETHYLENE) BY THE LACTATING BOVINE. Mohammad, K., S. Toma, J.W. Stull, F.M. Whiting and W.H. Brown, Department of Nutrition and Food Science, College of Agriculture, University of Arizona, Tucson, Arizona 85721.

Lactating dairy cows received daily oral doses of p,p'-DDE at four intake levels - 0, 0.1, 0.5 and 1.0 ppm - for 32 days. Milk from the three animals on each intake level was analyzed periodically during dosing and for 32 days afterwards. Metabolite deposition was determined

in brain, kidney, liver, lung, heart, lymph gland, spleen, gonad, udder, muscle and fetal tissues, in animals sacrificed at 32 days post-dosing. Milk DDE content increased during dosing to equilibrium at each intake level and then declined until slaughter. Detectable but insignificant DDE levels were noted in the analyzed tissues.

BINDING PROPERTIES OF MELANOIDINS. Molund, V., W.D. Powrie and H.F. Stich, Department of Food Science, University of British Columbia, Vancouver, British Columbia V6T 2A2.

Melanoidins are naturally occurring polymeric brown pigments formed in the Maillard browning reaction. Since these pigments have many types of functional groups, the possibility of binding carcinogens was considered. In this study, melanoidin fraction was prepared by ethanol precipitation of the pigment from an autoclaved lysine-glucose model system. The binding of aflatoxin B₁ and benz (a) pyrene by the melanoidin fraction was assessed by the Ames mutagenicity test, by equilibrium dialysis and by aryl hydrocarbon hydroxylase activation in rat intestines.

COULEUR ET CAROTENE DES JUS DE CAROTTE. Munsch, M.H. et R.E. Simard, Département des sciences et technologie de l'aliment et Centre de recherches en nutrition, Université Laval, Québec, Québec G1K 7P4.

En faisant varier certains paramètres dans le procédé de fabrication, on peut contrôler la qualité du jus de carotte, en particulier le blanchiment est nécessaire pour prévenir le brunissement à l'air, tandis que la macération enzymatique par des pectinases donne des jus plus colorés et plus riches en carotène. Au cours de la macération enzymatique, nous avons étudié l'effet du pH initial, de la température, de la dose d'enzymes et de la durée de macération sur la couleur (L, a, b de Hunter). La corrélation entre la couleur et la richesse en carotène a été examinée sur des jus expérimentaux avec ou sans enzymes, et sur des jus commerciaux.

CHANGES IN THE THERMAL BEHAVIOUR OF LEGUME AND OILSEED PROTEINS DURING PROCESSING. Murray, E.D. and S.D. Arntfield, Department of Food Science, University of Manitoba, Winnipeg, Manitoba R3T 2N2.

Changes in the thermal behaviour of fababeans field pea, soybean and Canola proteins during processing were monitored using differential scanning calorimetry (DSC). Increases in protein level, through the removal of hulls, oil or carbohydrates, generally resulted in increased transition enthalpies, with the greatest increases associated with proteins prepared using a micellar isolation technique. The DSC data suggest that the large endothermic transition observed when heating most proteinaceous material may represent a composite value reflecting contributions from, at least, the native protein in the starting material plus changes to these proteins and other interfering materials (e.g., phenolics) through processing.

THE ROLE OF PHYTIC ACID IN THE HARD TO COOK PHENOMENON IN FABABEANS. Murray, E.D. and M.M. Youssef, Department of Food Science and W. Bushuk, Department of Plant Science, University of Manitoba, Winnipeg, Manitoba R3T 2N2.

The hard to cook phenomenon in legumes has been observed for a long time; however, the mechanism responsible for this effect remains unknown. Several studies have implicated total seed phosphorus, and the work reported here has revealed that differences in starch gelatinization exist between hard and soft cooking samples of fababeans. These differences are readily influenced by native or added phytic acid and by added phytase. Phytic acid appears to be very much involved in final gelatinization results and may play a key role in the formation of a protein-phytic acid complex which indirectly affects starch gelatinization on cooking.

RAPESEED MEAL COMPONENTS INHIBITORY TOWARDS *BACILLUS STEAROTHERMOPHILUS*. Myhara, R.M., G. Blank and E.D. Murray, Department of Food Science, University of Manitoba, Winnipeg, Manitoba R3T 2N2.

Extracts of crude meal from *Brassica* species, *B. napus* (var. Tower) and *B. campestris* (var. Candle), isolated by either water, methylene chloride, or methanol extraction, were shown to exhibit inhibitory activity on bioassay plates employing *Bacillus stearothermophilus*. The extract obtained using hexane or chloroform showed only slight activity. Preliminary investigations have shown that the component(s)

do not belong to the major group of mycotoxins known as aflatoxins, sterigmatocystin, ochratoxin A, citrinin, penicillic acid, patulin and zearalenone. Partial purification by ultrafiltration membranes has shown that the component(s) have a molecular weight between 1,000 and 5,000 d. The inhibitory effect has also been shown to be present in whole unprocessed rapeseed.

DERANCIDIFICATION OF MILK BY ACTIVATED CARBON ADSORPTION. Nakai, S., K.P.Y. Cheung and L.P. Voutsinas, Department of Food Science, University of British Columbia, Vancouver, British Columbia V6T 2A2.

Activated carbon was used for adsorbing fatty acids from hydrolytically rancid milk. A 2 x 40 cm jacketed column was packed with 40 g of granular carbon, Calgon type CPG, and 400 mL of milk was pumped through the column at 60°C at a flow rate of 1.3 mL/min. The acid degree value of milk decreased from 2.6-1.1 without a sign of declining adsorptivity. The treated milk was whiter and blander than untreated milk. The temperature and flow rate were critical for the derancidification efficiency. Granular carbon was definitely advantageous over powdered carbon due to less leakage of carbon into the treated milk.

PROTEASE ACTIVITY IN FIG CELL SUSPENSION CULTURES. Nilsson, E.K. and P.M. Townsley, Department of Food Science, University of British Columbia, Vancouver, British Columbia V6T 2A2.

Commercial ficin preparations are currently obtained from latex of immature figs, *Ficus carica*. This investigation was conducted to determine the feasibility of enzyme production *in vitro*. Standard methods of leaf tissue excision were employed for callus development, and cell suspension cultures started from callus were maintained at 28°C in darkness. Proteolytic activity, as determined by a modification of the Food Chemicals Codex method for papain, was variable among cell lines over a 4 week period. Numerous medium supplements were assessed for possible stimulatory effects. Nitrate at 5-25 mM was crucial for good growth. Three percent skimmed milk, or the fresh casein and whey fractions thereof, all doubled enzyme activity. Some improvement was also evident using lactose, citrate and casein hydrolysate. Thiol reagents, though required for enzyme activation during assay, had no effect when added to the growth medium.

CHEMICAL CHANGES OCCURRING IN CAROTENOIDS DURING FOOD PROCESSING. Onyewu, P.N. and H. Daun, Department of Food Science, Rutgers University, New Brunswick, New Jersey 08903.

Carotenoids are one of the most widespread minor components of food. This unique group of substances contributes to colour, nutritive value and flavour of many food products. During processing and storage, carotenoids undergo isomerization, cyclization, oxidation and other reactions. Several low molecular volatile degradation products of carotenoids have been reported, while little is known on the nonvolatiles.

ABRASIVE TYPE DEHULLING OF GRAIN LEGUMES. Oomah, B.D., R.D. Reichert and C.G. Youngs, Prairie Regional Laboratory, National Research Council of Canada, Saskatoon, Saskatchewan S7N 0W9.

An abrasive type batch dehuller (4-7 kg), suitable for dehulling grain legumes, was built and tested. Resinoid disks or a combination of resinoid disks and carborundum stones mounted on a horizontal shaft provide the abrasive action. Soybeans, fababeans, mung beans, field peas, kidney beans, lentils and cowpeas were effectively dehulled at extraction rates of 74-87%. Dehulling efficiency, which expresses the proportion of actual hull material in the bran fraction, was developed to rank the performance of the legumes in the machine. Soybean dehulling was most efficient (DE = 0.72), while brown cowpeas was least efficient (DE = 0.11).

OXIDATION OF BUTTER AT LOW INTENSITIES OF FLUORESCENT LIGHTS. Paquette, G.J., D.B. Emmons, D.A. Froehlich and D.C. Beckett, Food Research Institute, Research Branch, Agriculture Canada, Ottawa, Ontario K1A 0C6.

A previous experiment showed that nine wrappers, except aluminium foil, allowed oxidized flavour to develop even at 400 lx/1 day. To assist in developing transmission standards for wrappers, butter was exposed under Saran to levels of light ranging from 50-400 lx/2 days. An expert panel detected very slight oxidized flavour even at the lowest intensity, equivalent to 2.5% transmission of a previously selected

standard of 2,000 lx/2 days. It was concluded that very little exposure to fluorescent lights results in detection of oxidized flavour on the surface of butter. Peroxide values, percentage detection of oxidized flavour and percentage downgrading were closely correlated.

QUALITY OF PRINTED BUTTER DURING FROZEN STORAGE. Paquette, G.J., D.B. Emmons, D.A. Froehlich and D.C. Beckett, Food Research Institute, Research Branch, Agriculture Canada, Ottawa, Ontario K1A 0C6.

Butter from each of two factories was stored for 12 mo at -21°C in ten different wrappers. The butter remained first grade in the interior and on the surface for the 12 mo with most wrappers. There was no evidence of serious oxidation on the surface with any wrappers as evidenced by increased peroxide values or by description of off-flavours as oxidized by an expert panel. Three wrappers, in particular two prototype aluminized parchments, had off-flavour described variously as, cardboard, box, paper or wrapper. One of the aluminized parchments also discoloured during storage, with patches becoming transparent and showing the yellow colour of the butter. In this experiment frozen storage of high quality butter for 1 year resulted in a high quality product.

COMPARISON OF FIVE DIFFERENT SELECTIVE PLATING MEDIA FOR ISOLATION OF *CAMPYLOBACTER JEJUNI* FROM FRESH WHOLE CHICKENS. Park, C.E. and Z.K. Stankiewicz, Microbiology Research Division, Bureau of Microbial Hazards, Food Directorate, Health Protection Branch, Health and Welfare Canada, Ottawa, Ontario K1A 0L2.

Five selective agar media (Butzler, a modification of Butzler, Skirrow, a modification of Skirrow and Campy-BAP) were compared for the primary isolation of *Campylobacter jejuni* from naturally contaminated fresh whole chickens. Each of fifty chickens was washed by massaging with brucella broth (250 mL) in a sterile plastic bag. The cells in the washings were concentrated by centrifugation at 16,000 x g for 30 min at 4°C, and the pellet was suspended in 5 mL of brucella broth. Three loopfuls of cell suspension were plated in triplicate on each plate; the plates were incubated at 42°C for 48 h under the gas mixture (5% O₂, 10% CO₂, 85% N₂). The isolation rate from the five media was: Campy-BAP (66%) > modified Skirrow (62%) > Skirrow (56%) > modified Butzler (50%) > Butzler (48%).

THE EFFECT OF SUPPLEMENTARY VITAMINS AND AMINO ACIDS ON THE CLINICAL BIOCHEMISTRY AND FREE AMINO ACIDS IN THE PLASMA OF CHICKS WITH AFLATOXICOSIS. Park, L.E., M.N. Voigt and J. Veltmann, Department of Biochemistry, Memorial University of Newfoundland, St. John's, Newfoundland A1B 3X9.

Aflatoxicosis has been observed to induce characteristic plasma free amino acid and clinical biochemistry profiles in broiler chicks. The effects of administering a series of nutritional factors on these blood components and the performance of chicks with aflatoxicosis has been studied and compared in strains of broiler chicks which vary in their susceptibility to aflatoxin.

MANUFACTURING OF *GHEE* UTILIZING SUBSTANDARD, MARKET REJECT MILKS AND WHEY BUTTER AND BUTTER, USING INEXPENSIVE EQUIPMENT. DOMESTIC AND EXPORT MARKET POTENTIAL OF *GHEE*. Patel, I.R. and D.H. Thompson, Teeswater Creamery, Teeswater, Ontario N0G 2S0.

Butteroil, the equivalent of *Ghee*, is manufactured by very few dairy plants in Canada, using expensive equipment and mostly good quality cream or butter. Substandard or market return milk and substandard butter, as well as whey butter, is often a disposal problem experienced by some dairies. A simple and innovative procedure is suggested to manufacture high quality *Ghee*. *Ghee* manufactured by this method is superior in flavour and keeping quality. Such *Ghee* has fewer oxidative problems than butteroil made using centrifugal separation procedures.

An increase in the domestic market use of *Ghee*, as well as its export potential, is favourable.

MODIFIED DICKERSON METHOD TO STUDY TEMPERATURE DEPENDENCE OF THERMAL DIFFUSIVITY OF FOODS. Ramaswamy, H.S. and M.A. Tung, Department of Food Science, University of British Columbia, Vancouver, British Columbia V6T 2A2.

The classical thermal diffusivity tube method was modified with respect to equipment design and data analysis to generate thermal diffusivity values as a function of temperature in the range of interest in thermal processing operations. The major change in the design was the fabrication of an end insulated cylindrical pressure cell capable of withstanding thermal processing temperatures. A multi-stage regression technique was employed to obtain thermal diffusivity at different temperatures. The temperature range for the regression analysis was expanded by utilizing a significant portion of the lag period through an iterative computer programming technique.

UNSTEADY TEMPERATURE IN SHORT TIME HEATED REGULAR THERMALLY CONDUCTIVE SOLIDS. Ramaswamy, H.S. and M.A. Tung, Department of Food Science and K.V. Lo, Department of Bio-Resource Engineering, University of British Columbia, Vancouver, British Columbia V6T 2A2.

The infinite summation series describing the heat transfer into regular conductive solids is usually approximated by the first term of the series when the heating time is relatively long. For short time heating ($Fo < 0.2$), the errors involved because of the first term approximation are significant (up to 25% for an infinite slab at $Fo = 0.02$). This is because of the curvilinear relationship between the temperature and time at $Fo < 0.2$. Simplified relationships for estimating the curved portion of the heating or cooling curve at $0.001 < Fo < 0.2$, based on the coefficients for the first term approximation situation, are described in this paper.

RELATIONSHIP BETWEEN GLYCEMIC INDEX AND LECTIN CONCENTRATION OF LEGUMES AND OTHER FOODS. Rea, R.L., L.U. Thompson and D.J.A. Jenkins, Department of Nutritional Sciences, Faculty of Medicine, University of Toronto, Toronto, Ontario M5S 1A8.

Lectins, commonly found in plant foods, may contribute to slow absorption of carbohydrate. This slow absorption is greatly emphasized in legumes, which are also high in lectins. Several foods were assayed for lectin concentration and a negative correlation with glycemic index was observed. As heat is known to destroy lectins and improve the nutritional value of legumes, red kidney beans were treated under varying temperatures and times, and then assayed for lectin concentration. A significant reduction in concentration was seen over time at all temperatures. Glycemic indices also correlated with these lectin concentrations.

THE MAJOR PROTEIN FRACTION IN OATS "GLOBULINS." Robert, L., A. Cudjé and I. Altosaar, University of Ottawa, Ottawa, Ontario K1N 9B4.

The oat grain displays the protein of best nutritive value of all the cereals. However, controversy still surrounds the basic delineation and quantitation of the globulin and glutelin protein fractions (Kim *et al.*, *Physiol. Vég.* 17(2):231, 1979). Estimates on their amount vary from 25-80% for both these classes. The proper separation of these fractions is essential to characterize or utilize them individually. Work was undertaken to study the glutelin fraction. Results indicate a significant difference (10-85%) in protein yield depending on the extraction procedure utilized. Electrophoretic analysis (SDS, PAGE and IEF) also shows an overlap in the solubility of the proteins belonging to the so-called glutelins and globulins.

SCREENING CHEMICAL COMPOUNDS FOR THEIR POTENTIAL IN EXTENDING THE SHELF LIFE OF LETTUCE. Rossit, R. and V. DeQuoy, Nova Foods Inc., Montréal, Québec H1Z 3B6.

A practical method has been developed whereby chemical compounds can be screened for their effectiveness in extending the usable shelf life of freshly shredded lettuce. Of interest were those compounds that exhibited inhibitory characteristics on the deterioration of biochemical processes inherent to the shredded lettuce system. The procedure calls for dissolving the chemicals in water, soaking the shredded lettuce for various times and temperatures, centrifugation and storing under controlled conditions. Periodic analyses (physical, chemical, microbiological) were carried out to determine the effectiveness in extending the shelf life for each chemical. Summary of results: ascorbic acid (0.1-0.5%) = 300% increase, EDTA (0.01-0.1%) = 300% increase, gibberellic acid (1-10 ppm) = 350% increase and 2,4 dichlorophenoxyacetic acid (10-100 ppm) = 250% increase. Significant extension of shelf life is possible by introducing certain chemicals to the lettuce.

ALKALINE EXTRACTION OF PROTEIN FROM SPENT HONEY BEES. Ryan, J.K. and P. Jelen, Department of Food Science and W.C. Sauer, Department of Animal Science, University of Alberta, Edmonton, Alberta T6G 2N2.

Adult honey bees were evaluated as a potential source of human food grade protein. Bees collected at honey harvest were 49.9% protein, 7.54% lipid (including wax) and 27.1% reducing sugar (moisture free basis). Bees were homogenized and body proteins solubilized in alkali, chitin removed by filtration, and protein recovered by acid precipitation. Amount of protein solubilized varied with treatment, from negligible without alkali (pH 6.1) to 93% of theoretical maximum with severest treatment at pH 11.2. Precipitate was 66.3% protein, 9.4% lipid and 7.9% ash. Heads, thoraces and abdomens were separated and treated. Head precipitate was purple, odourous and contained 19.3% of whole body precipitate, which was 70.1% protein. Thorax protein was white and odourless. Abdomen precipitate was brown, sweet, 44.9% of body precipitate and only 36.6% protein. Amino acid composition of these proteins was analyzed.

CONSUMER PREFERENCES AND HANDLING PRACTICES OF POTATOES. Ryland, D. and R. Diamant, Department of Foods and Nutrition, University of Manitoba, Winnipeg, Manitoba R3T 2N2.

To provide a basis for the evaluation of table stock varieties of potatoes, a survey of Manitoba consumers was conducted regarding their criteria for the selection and assessment of potato quality. Also determined was their behaviour regarding consumption, handling and cooking methods. The survey, done by telephone, utilized a questionnaire based on information from focus group interviews. Random telephone numbers (chosen by the plus one method) were called by professional interviewers. In each household reached, the major food preparer was interviewed, 200 in Winnipeg and 200 in other Manitoba locations. Frequencies of responses were related to certain characteristics of the samples.

ATTACHMENT OF *SALMONELLA TYPHIMURIUM* TO TWO TYPES OF CHICKEN SKIN. Sahasrabudhe, J.M. and B.J. Skura, Department of Food Science, University of British Columbia, Vancouver, British Columbia V6T 2A2.

Attachment of *Salmonella typhimurium* to lean (Type I) and fatty (Type II) chicken broiler leg skin was evaluated. Representative legs, after dipping in attachment medium containing 10^8 *S. typhimurium*/mL, were subjected to the following procedures 0, 5, 10 and 15 min after inoculation: (1) no washing (inoculated), (2) washing with sterile attachment medium (inoculated-washed), and (3) washing with sterile attachment medium containing 1% Tween 80 (inoculated-surfactant washed). More *S. typhimurium* attached to Type II skin than to Type I skin ($P < 0.01$). *S. typhimurium* population of inoculated and inoculated-washed (with and without Tween 80) skin was significantly different ($P < 0.01$) but was similar on inoculated-washed and inoculated-surfactant washed skin ($P > 0.05$).

XANTHAN GUM: A UNIQUE FOOD HYDROCOLLOID. Sanderson, G.R., Kelco, 8355 Aero Drive, San Diego, California 92123.

Aqueous solutions of xanthan gum, the extracellular polysaccharide from *Xanthomonas campestris*, possess a number of extremely useful rheological properties. They exhibit a yield value, are highly pseudoplastic and have high viscosities at low gum concentrations. In addition, viscosity is not significantly reduced by large changes in pH, temperature and ionic strength. These properties make xanthan gum a unique thickener and stabilizer for a wide range of food products. The widespread use of xanthan gum in the food industry is also partly the result of its good compatibility and, in some cases, favourable interactions with other food ingredients.

N-NITROSODIMETHYLAMINE (NDMA) AND N-NITROSOPROLINE (NPRO) IN MALT AND BEER. Sen, N.P., S. Seaman and L. Tessier, Food Research Division, Food Directorate, Health Protection Branch, Ottawa, Ontario K1A 0L2.

The average levels of NDMA in both the domestic and imported beers seemed to have decreased significantly during the last 3 years thus confirming the efficacy of the improved malt drying techniques introduced recently in various countries. The details will be presented at the meeting. The development of a rapid method (based on GLC-TEA[®] analysis of the methyl-ester) for determining NPRO in malt and beer, and some recent data on the NPRO levels in these products, will also be reported. Both malt (5-113 ppb) and beer (0.5-3.9 ppb) were found to contain traces of NPRO.

ALTERNATIVE MEAT CURING SYSTEMS. I. COOKED CURED MEAT PIGMENT. Shahidi, F., L.L. Diosady and L.J. Rubin, Department of Chemical Engineering and Applied Chemistry, University of Toronto, Toronto, Ontario M5S 1A4.

In an effort to develop alternative meat curing systems to substitute the traditional curing agent, sodium or potassium nitrite, we have investigated the preparation of cooked cured meat pigment, dinitrosyl ferrohemochrome. The precursor to this "synthetic" pigment, hemin, is obtained in pure form and in good yield from blood of slaughtered animals using acetic acid/salt or acetic acid/acetone/salt solutions. Dinitrosyl ferrohemochrome was prepared by the reaction of hemin with sodium nitrite or nitric oxide and a reductant in buffered solutions. This pigment is extremely air and light sensitive and the work on its preservation and application is under way.

THE OPTIMIZATION OF CONTINUOUS STERILIZATION. Sidaway, D. and R. Kok, Department of Agricultural Engineering, Macdonald Campus of McGill University, Ste. Anne de Bellevue, Québec H9X 1C0.

A set of computer programs was developed to find the best holding time and operating temperature to minimize an objective function while maintaining the lethality of a continuous process. The objective function was based on a number of nutrients and their destruction characteristics. In the model, food rheology, fluid mechanics, required lethality and several operating parameters were taken into account. Equipment and program parameters such as tube length, increment size and temperature increment could be manipulated or be determined by the program. Results obtained from the program were compared to those reported in the literature.

EXTENDED FRANKFURTER SHELF LIFE UNDER NITROGEN. Simard, R.E. and L. Laleye, Centre de recherche en nutrition et département de sciences et technologie des aliments, Université Laval, Québec G1K 7P4 and R. Holley, Institut de recherche sur les aliments, Agriculture Canada, Ottawa, Ontario K1A 0C6.

Frankfurter shelf life was studied by packaging under nitrogen and using vacuumized frankfurters as control. The effect of light and dark storage for periods of 49 days at -4, 0, 4 and 7°C was also compared. The frankfurter quality was assessed by monitoring changes in microbial counts (lactobacilli, psychrotrophics, molds and yeasts, as well as coliform bacteria) and physico-chemical characteristics (extract release volume, gas composition, pH, colour and odour).

Nitrogen packaged frankfurters had lower psychrotrophic and lactobacilli counts than vacuum ones, and counts were lower under light than under dark. After 14 days, vacuum packaged frankfurters stored at 3°C under light were considered unfit to eat, while nitrogen packaged frankfurters under identical conditions were still suitable for consumption after 28 days. Frankfurter greening and discolouration seldom develop under nitrogen.

PURIFICATION, CHARACTERIZATION AND UTILIZATION OF TRYPSIN FROM THE GREENLAND COD. Simpson, B.K. and N.F. Haard, Department of Biochemistry, Memorial University of Newfoundland, St. John's, Newfoundland A1B 3X9.

Trypsin was purified from Greenland cod by the successive steps of ammonium sulphate fractionation, acetone precipitation and affinity chromatography. The trypsin had a pH optimum between 7 and 8 and was most stable at moderately alkaline pH. This trypsin was more heat labile than its bovine counterpart and both types were effective in preventing Cu induced off flavour development in raw milk samples, but while rock cod trypsin lost all its activity after pasteurization of the milk at 70°C, bovine trypsin retained about a third of its original activity after the same pasteurization treatment. Finally, CD spectra studies showed the rock cod trypsin to be more random coiled than the bovine trypsin.

EFFECT OF SUCCINYLACTION ON THE PROTEIN QUALITY AND URINARY EXCRETION OF BOUND AND FREE AMINO ACIDS. Siu, M. and L.U. Thompson, Department of Nutritional Sciences, Faculty of Medicine, University of Toronto, Toronto, Ontario M5S 1A8.

The net protein ratio (NPR) of whey protein concentrate succinylated at four different levels was determined in order to establish an appropriate level of modification which will not adversely affect the protein quality. The utilization of the absorbed succinylamino acids was also determined in rats by examining the urinary excretion of bound and free amino acids. Succinylated whey concentrate (SWC) with 37% succinylation is still a good quality protein with NPR higher than

casein. At higher levels of succinylation, the NPR was adversely lowered. Rats fed SWC had high urinary nitrogen excretion, but little of the succinyllysine and none of the succinylcysteine and succinylthreonine were recovered as bound amino acids in the urine. Apparently these amino acids were partially catabolized to forms that were unavailable to the body. Further metabolic and toxicity studies of the succinylamino acids are recommended.

INTESTINAL MICROBE SUBSTRATE INTERACTION IN FLATUS INDUCTION. I. FECAL MICROFLORA AND α -GALACTOSIDE UTILIZATION. Skura, B.J. and E.K. Nilsson, Department of Food Science, University of British Columbia, Vancouver, British Columbia V6T 2A2.

Recent research by several groups seems to indicate a relationship between the flatus potential of white navy beans and their α -galactoside content. The purpose of this investigation was to elucidate the role of intestinal microflora in this phenomenon. Anaerobic bacteria were isolated from stool specimens collected aseptically and anaerobically. Selected isolates were tested for gas production from some α -galactosides in basal medium, using a syringe method. Raffinose prefermented by *Saccharomyces cerevisiae* yielded gas volumes paralleling melibiose in nineteen of twenty-two cultures. On the basis of cell numbers, at least ten times more gas was produced from fructose than melibiose by most isolates. Both β -fructosidase and α -galactosidase activities are involved in raffinose utilization, though not necessarily from one source. HPLC is being employed to determine α -galactoside utilization patterns.

THE APPLICATION OF RESPONSE SURFACE METHODOLOGY TO SHELF LIFE STUDIES ON A GAS PACKAGED BAKERY PRODUCT. Smith, J.P., E.D. Jackson and B. Ooraikul, Department of Food Science and R. Hardin, Department of Animal Science, University of Alberta, Edmonton, Alberta T6G 2P5.

Response surface methodology (RSM) consists of a group of multiple regression techniques used in the empirical relationship between one or more measured responses on the one hand and a number of input variables on the other. In this study, RSM was used to determine the effect of specified levels of environmental factors such as CO₂:air ratio, a_w, pH and storage temperature on the activity of selected spoilage isolates (*Leuconostoc* species, *Aspergillus niger*). From these preliminary model investigations, further regression designs were used to determine the levels of parameters required to optimize the shelf life of a gas packaged bakery product.

POTENTIAL OF WILD OATS AS A HIGH PROTEIN FOOD. Sosulski, F.W. and K. Elkowicz, Department of Crop Science, University of Saskatchewan, Saskatoon, Saskatchewan S7N 0W0.

Wild oats are a serious contaminant of cereal grains and large quantities are separated during grain cleaning. The seed contains 30-35% of hulls but, after dehulling, the groat composition is 20% protein, 55% starch and 8% oil. Mineral and vitamin contents also exceed those of the domestic oat. The protein is well balanced in essential amino acids, the lysine and methionine contents being 3.8% and 1.6%, respectively. In rat feeding experiments, weight gains on groats from wild oats exceed those of domestic oat diets by 25%, while PER values are about the same at 2.3. Neutral lipids represent 87% of the crude lipid fraction, the fatty acid composition being 14% palmitic, 47% oleic and 37% linoleic acids. The wild oat has an active lipase. The groat can be rolled into quick or instant cooking flakes and, in organoleptic tests, cannot be distinguished from domestic oat flakes in appearance or flavour.

EVALUATION OF THE FOSS MARK III MILKOTESTER FOR PAYMENT OF FARM SEPARATED CREAM. Szijarto, L., Central Milk Testing Laboratory, Ontario Ministry of Agriculture and Food, Guelph, Ontario N1E 3G3 and F.R. van de Voort, Department of Food Science, University of Guelph, Guelph, Ontario N1G 2W1.

The Foss Mark III Milkotester was evaluated as an alternative method to the Babcock for payment of farm separated creams. This instrument was chosen to take advantage of its built in dilution capability to simplify sample preparation to dilute creams to fat levels commonly found in milks. Processed sweet creams, inoculated with lactic acid cultures, were initially tested to assess any effect on the results as a function of acidity. Low results were obtained for acidic creams, but this phenomenon was not the result of low pH directly, but due to gas formation by the fermentation and the corresponding displacement of fat by gas. This effect was not significant in the case of farm separated creams, due to the fact that heating of the samples, generally to 60°C,

was required to obtain a uniform sample consistency. In all cases, the Mark III Milkotester was found to be as accurate as the Babcock method for the analysis for fat in creams, and the calibration was found to hold for a substantial period of time. Based on the results of this study, the Mark III is recommended as a simpler, cleaner and generally more rapid method of analyzing farm separated creams for payment purposes.

PROCESSING, DIGESTIBILITY AND GLYCAEMIC RESPONSE TO A LEGUME. Thorne, M.J., D.J.A. Jenkins, L.U. Thompson, A.V. Rao and T. Francis, Department of Nutritional Sciences, Faculty of Medicine, University of Toronto, Toronto, Ontario M5S 1A8.

Processing is an important determinant of the glycaemic response to lentils. When eaten by healthy volunteers, 20 min boiled lentils produced a flatter blood glucose response than bread. This was unaltered by blending the lentils to a paste or boiling them for a further 40 min. However, the blood glucose response was greatly enhanced by drying the blended lentils for 12 h at 250°F. *In vitro* digestion with human saliva showed the rate of sugars released from the food related positively to the blood glucose rise. Breath hydrogen studies indicated that carbohydrate malabsorption was too small to account for these differences.

MASS TRANSFER IN CELLULAR FOODSTUFFS IN CONTACT WITH AQUEOUS FREEZANTS. THEORETICAL MODEL AND SIMULATION. Toupin, C.J. and M. LeMaguer, Department of Food Science, University of Alberta, Edmonton, Alberta T6G 2P5.

Direct contact coolants (aqueous freezants are mixtures of water-ethanol-salts or sugar) are used to improve heat transfer at the surface of the food. Simultaneously, water is being withdrawn by osmotic effect, and salt and sugar enter the product by diffusion. A mathematical and computer model of the above process has been developed in terms of mass transport phenomena. The influence of the living cells, as well as the tissue structure, have been taken into account in predicting the behaviour of the mass transfer process.

WHEY PROCESSING: THE PRODUCTION OF A FOOD STABILIZER BY *S. LACTIS LONGI*. Townsley, P.M., D. Macura and D.S. Smith, Department of Food Science, University of British Columbia, Vancouver, British Columbia V6T 2A2.

The economic utilization of waste whey from the dairy industry remains an unresolved problem for most of the industry. *S. lactis longi* grows well on whey and deproteinized whey producing a highly viscous medium. This viscous material, tentatively identified as a glycoprotein, can be dried and then reconstituted, regaining its original viscosity contribution. The production of this fermentation product and its application to the food industry will be discussed.

ANALYSIS OF AFLATOXINS BY HPLC USING A DUAL DETECTION TECHNIQUE. Tran, Y., Weston Research Centre, 1047 Yonge Street, Toronto, Ontario M4W 2L3.

Aflatoxins in peanut, peanut butters and other nut products were assayed by HPLC using a dual detection technique. Precolumn derivatization using trifluoroacetic acid and post column derivatization using iodine provided the required sensitivity plus confirmation of B₁ and G₁, with minimal sample cleanup.

A comparison of data obtained by this method and by the standard thin layer chromatographic method is presented.

AIR CLASSIFICATION OF GRAIN LEGUMES: CUT SIZE EFFECTS. Tyler, R.T. and C.G. Youngs, National Research Council, Saskatoon, Saskatchewan S7N 0W9 and F.W. Sosulski, Department of Crop Science, University of Saskatchewan, Saskatoon, Saskatchewan S7N 0W0.

Samples of green lentils, Great Northern beans, fababeans, field peas and navy beans were pin milled and air classified at five cut sizes into coarse (starch rich) and fine (protein rich) fractions. Cut size had a marked effect on both the yield and the composition of the fractions. Differences among legumes were observed in: (1) fraction yield and composition at a particular cut size, and (2) the sensitivity of fraction yield and composition to changes in cut size. Optimal separation of protein and starch was achieved at cut sizes of 15-20 microns.

SENSORY QUALITY OF GRASS FED, FORAGE FINISHED BEEF. Vanderstoep, J., Department of Food Science, University of British Columbia, Vancouver, British Columbia V6T 2A2 and R.J. Forrest, Agriculture Canada, Agassiz, British Columbia V0M 1A0.

The sensory quality of meat from animals fed on grass and finished on forage was studied. Steers were slaughtered after coming off pasture or after having been fed forage for 6, 12 or 18 weeks. The 9-11th ribs were used for carcass evaluation. One adjacent two rib cut and samples of kidney and chuck fat were used for sensory and objective colour and texture analysis, after frozen storage. Length of time of forage feeding did not appear to affect the meat's juiciness, tenderness, flavour intensity and amount of connective tissue. Fat colour, as judged by a consumer panel, was acceptable.

INFLUENCE OF CONTROLLED ATMOSPHERIC COMPOSITION AND HYPOBARIC STORAGE ON *SALMONELLA* SP. WITH APPLICATION TO THE EXTENSION OF THE SHELF LIFE OF POULTRY. Voigt, M.N. and N.F. Haard, Department of Biochemistry, Memorial University of Newfoundland, St. John's, Newfoundland A1B 3X9.

Modified hypobaric storage conditions were created by premixing combinations of CO₂, N₂, O₂ and/or CO for use as the bleeding gas for a hypobaric system. Various combinations of the gases were evaluated for their effect on the growth of four species of *Salmonella* cultured in nutrient broth, as well as on the *Salmonella* flora of poultry. Gas combinations which resulted in the maximal inhibition of the *Salmonella* were applied to a poultry shelf life study to evaluate the quality and sensory characteristics after extended storage.

RELATIONSHIPS BETWEEN PROTEIN HYDROPHOBICITY AND THERMAL PROPERTIES OF FOOD PROTEINS. Voutsinas, L.P. and S. Nakai, Department of Food Science, University of British Columbia, Vancouver, British Columbia V6T 2A2 and V.R. Harwalkar, Food Research Institute, Agriculture Canada, Ottawa, Ontario K1A 0C6.

Hydrophobicity (S_e) measured fluorometrically, using *cis*-parinaric acid as a probe, after protein solutions were heated in the presence of SDS was more closely related to the thermal properties than the surface hydrophobicity (S_o) measured without heating the protein solutions. Significant correlations of $R^2 = 0.740$ ($P < 0.05$) and $R^2 = 0.839$ ($P < 0.05$) were observed for gelation rating of eight proteins with S_e and SH groups or SH + reduced SS groups, respectively. Similarly, R^2 values of 0.988 ($P < 0.01$) and 0.995 ($P < 0.01$), respectively, were obtained for thickening (viscosity change) of the proteins upon heating. Heat coagulability (solubility decrease) was also significantly correlated with S_e and SH groups ($R^2 = 0.876$, $P < 0.05$).

EVALUATION OF CELL AND TRANSPORT PARAMETERS IN HEAT TRANSFER PROCESSES USING THE TTC METHOD OF VIABILITY ASSAY. Weatherall, A.E. and M. LeMaguer, Department of Food Science, University of Alberta, Edmonton, Alberta T6G 2P5.

The TTC method of viability assay was used to approximate heat transfer coefficients in heating and freezing processes applied to carrots by virtue of the visualization of the temperature front propagation. By modelling heating as unsteady state conduction in a semi-infinite solid, it was calculated that death of carrot tissue occurs at about 53°C. Plank's equation was used to describe freezing and it was found that death of cells coincided with freezing. The TTC method provides a simple way of evaluating cell and transport parameters in initial analyses of heat transfer processes applied to plant material.

LOW BLOOD GLUCOSE RESPONSE TO BEANS IN DIABETICS. Wolever, T.M.S., D.J.A. Jenkins and M.J. Thorne, Department of Nutritional Sciences, Faculty of Medicine, University of Toronto, Toronto, Ontario M5S 1A8.

Beans have recently been used in treating diabetes and hyperlipidemia. However, there is little data on the acute physiological response to feeding beans. We therefore measured glycemic responses in diabetics for 3 h after test meals containing 50 g carbohydrate portions of five varieties of dried legumes and eight other more commonly eaten foods (breads, pasta, rice, potato, breakfast cereals). Both the mean peak rise and area under the curve of blood glucose concentration were 25% less than those for the other foods ($P < 0.001$). These results provide a rationale for the use of dried beans in diabetic diets.

PRODUCTION OF HIGH FRUCTOSE SYRUP FROM BEET MOLLASSES. Wong, P.W. and B. Ooraikul, Department of Food Science, University of Alberta, Edmonton, Alberta T6G 2P5.

Diluted beet molasses ($\approx 30\%$ t.s.s. w/v) was decolourised by

ultrafiltration and activated carbon, which removed 65.7% and 29.5% of the original colour, respectively. The resulting light brown syrup was then purified with ion exchange resins. Column chromatography with ion exchange resins was used to hydrolyze, separate and isomerize the purified syrup. A strong cationic resin (H^+ form) was used for the hydrolysis, then a cationic resin (CA^{2+} form) was used for separation of glucose and fructose, and a strong anionic resin (OH^- form) for isomerization of the glucose fraction. The fructose content of the total sugars was 60-70% by weight in the resulting syrup.

DETERMINATION OF A PHYTOESTROGEN, COUMESTROL, IN ALFALFA SPROUTS. Yada, S.A. and J. Vanderstoep, Department of Food Science, University of British Columbia, Vancouver, British Columbia V6T 2A2.

Germinated alfalfa seeds, or "sprouts," were examined for their content of phytoestrogens, particularly coumestrol. The ability of coumestrol to fluoresce upon exposure to UV light was employed as the basis for chromatographic analyses of coumestrol in alfalfa. Visual comparisons of fluorescence intensities between the coumestrol standard and unknown spots on silica gel TLC plates could serve as a means for a rapid, semi-quantitative analysis. The use of reverse phase HPLC to provide a more accurate quantitative analysis was also investigated. The content of coumestrol has been found to increase during germination of other legumes, therefore the effect of various germination conditions on the accumulation of coumestrol in alfalfa sprouts was studied. Light intensity, rinse frequency and germination time were the major conditions examined.

EFFECT OF PHYTIC ACID ON RATE OF STARCH DIGESTIBILITY. Yoon, J.J.H., L.U. Thompson and D.J.A. Jenkins, Department of Nutritional Sciences, Faculty of Medicine, University of Toronto, Toronto, Ontario M5S 1A8.

The effect of phytic acid on rate of starch digestibility was studied *in vivo* and *in vitro*. As observed in humans, glycaemic index negatively correlated with phytic acid intakes. *In vitro* dialysis system involving human saliva at physiological pH and temperature showed that in the presence of phytate (up to 2%), the rate of raw wheat starch digestibility was reduced significantly by 50%. This was reversed by the addition of calcium which is known to complex phytic acid. *In vitro* digestibility of starch in unleavened bread with added phytate was also decreased, as was observed with raw starch.

ELEMENTAL ANALYSIS OF CANADIAN, AMERICAN AND EUROPEAN WINES BY PIXE. Zee, J.A., R.E. Simard, I. Szöghy and J. Tremblay, Département de sciences et technologie des aliments and Centre de recherche en nutrition, Université Laval, Ste-Foy, Québec G1K 7P4.

Quantitative analysis of P, S, Cl, K and Ca in Canadian, American and European wines was performed by an energy dispersive X-ray fluorescence system (PIXE). Red wines had significantly higher P, S and K contents than white wines, but contained less Ca. When the wines from different countries were compared, P, K and Ca contents in all red wines were not significantly different; French red wines contained the lowest S and Cl contents, while American red wines had the highest Cl content. In white wines, Ca contents were similar; the five elements were the highest in American wines and the lowest in Spanish wines. Bordeaux wines were highest in P, Cl, K and Ca contents and Bourgogne, in S content. Also, commercial wines had higher elemental contents than average. Canadian red wines contained the highest P content and above average S, K and Ca values. In red and white Canadian sherries, Cl content was about twofold that in wines and ciders. Canadian ciders had the lowest P, S, Cl and Ca contents, but the highest K content. Differences are probably due to the nature of raw materials and the various fermentation technologies used.

MECHANISM OF CAKE FLOUR CHLORINATION. Zellen, W.L. and V.F. Rasper, Department of Food Science, University of Guelph, Guelph, Ontario N1G 2W1.

Modification of wheat flour for cake production by chlorination has been used for many decades. The mechanism of this treatment is, however, still poorly understood. Rheological tests (alveography, extensigraphy) performed on a series of flours treated with different amounts of Cl_2 have indicated effects on the rheological parameters similar to those resulting from the presence of fast acting oxidizing agents (potassium iodate, azodicarbonamide). The ultimate baking properties of flours treated with these agents were not found to be comparable with those of the chlorinated ones. More recent studies suggested a possible involvement of the lipoyxygenase-linoleic acid system in the chlorination mechanism. The above system is known to enhance the gel forming power of gelatinized starch. Results on flours with different degree of chlorination support the lipoyxygenase-linoleic acid hypothesis, as a highly significant correlation was found between the degree of chlorination on one hand and both gel strength and gel thermal stability on the other.



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You are invited to submit original research papers and reviews for presentation in technical or poster sessions to the Technical Program Committee for consideration for the CIFST 26th Annual Conference in Ottawa, May 29 – June 1, 1983.

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Rules for preparation and submission of abstracts and presentation of papers will be published in the CIFST Journal, vol. 15, no. 4. Abstracts must be received no later than December 31, 1982.

Mail abstracts and obtain further information from Mr. Ian Campbell, 1983 CIFST Program Committee, Health Protection Branch, Health and Welfare Canada, Tunney's Pasture, Ottawa, Ontario K1A 0L2.

Vous êtes invités à remettre des communications portant sur des recherches originales ou des revues de littérature pour fins de présentation sous forme de sessions d'affiches ou techniques au Comité de programmation technique afin qu'elles soient considérées pour la 26^{ième} Conférence annuelle de l'ICSTA qui se tiendra à Ottawa du 29 mai au 1^{er} juin 1983.

Le thème de la Conférence 1983 est HORIZONS, un regard sur le futur, en liaison étroite avec la réalité d'aujourd'hui.

Les règlements pour la préparation et la soumission des résumés et la présentation des communications seront publiés dans le Journal ICSTA, vol. 15, no. 4. Les résumés doivent être reçus au plus tard le 31 décembre 1982.

Vous pouvez envoyer vos résumés et obtenir de plus amples renseignements de M. Ian Campbell, Comité de programmation, Conférence ICSTA 1983, Direction générale de la protection de la santé, Santé et bien-être social Canada, Parc Tunney, Ottawa, Ontario K1A 0L2.



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BOOK REVIEWS

VITAMIN C. J.N. Counsell and D.H. Hornig. Applied Science Publishers Ltd., Ripple Road, Barking IG11 0SA, Essex, England. 1981. 383 pp. \$64.00.

This book is based on the contributions of a number of acknowledged experts invited to attend the International Symposium on Vitamin C organized by Roche Products Limited, held on the 9th and 10th of April 1981 at the University of Warwick, U.K. The particular topics reviewed in this text can be divided into two categories: those relating to the nutritional value of vitamin C in man and those relating to the functional properties of vitamin C in food technology.

Although the functions, metabolism and requirements of vitamin C in man have been reviewed extensively in the past, this book presents current ideas and recent developments on the function of ascorbic acid in such physiological processes as the immuno-stimulation mechanisms, iron absorption mechanisms and lipid metabolism. The value and safety of high vitamin C intakes for normal and therapeutic use are presented, as are the effects of certain drugs, in particular aspirin, on the bioavailability of the vitamin.

In the food processing and technology area, the use of ascorbic acid in breadmaking, meat processing and beverage technology, and its value as an antioxidant are discussed in separate chapters. The question of its inhibitory effect on nitrosamine formation is also considered.

Each topic is treated succinctly in a ten to twenty page chapter for a total of nineteen chapters. The book must be commended for its wealth of reference material. The readership for this publication would include food scientists concerned with food chemistry and technology, and nutritionists in the area of clinical research.

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QUALITY IN STORED AND PROCESSED VEGETABLES AND FRUIT. P.W. Goodenough and R.K. Atkin. Academic Press Inc., 111 Fifth Avenue, New York, New York 10003, U.S.A. 1981. 398 pp. \$62.00.

The text begins with an inaugural lecture which is an excellent overview of the present state of affairs relating to the maintenance of quality of horticultural products in the present day food industry. This introduction points out many of the problems of various phases of the industry and indicates some of the important areas for future research efforts. The rest of the text can best be summarized in sections.

Section I attempts to assess what attributes are involved in determining quality of fruits and vegetables; the authors have effectively addressed the sensory and texture topics. Two other areas which would have been valuable additions to this section would have been chapters dealing specifically with colour and flavour.

Section II points out the important role that plant breeding and cultural practices play in determining final product quality. The authors have done a good job of identifying and discussing many of the pre-harvest factors which affect the growth and development of fruits and vegetables. Their discussions provide insights into the interactions of heredity, environmental and cultural elements which relate to product attributes.

The first phase of Section III, which deals with the physiological aspects of quality at harvest, is a very comprehensive treatment of the biochemistry of development, ripening and differentiation of some selected horticultural crops. The inclusion of some methodology in these chapters is pertinent and helpful for researchers working in this field. The second phase of Section III, dealing with harvesting and handling, outlines some criteria for determining optimum harvest maturity and storage stability of selected fruits. It also discusses the development of harvesting equipment and how product quality may be affected by changes in equipment and/or methods for harvesting.

Section IV discusses post-harvest changes and is very effective in detailing several of the important types of physiological reactions and disease problems which may have deleterious effects on product quality after harvest and during storage. Methods for controlling many of the disorders and diseases are discussed. Post-harvest storage conditions and their relationship to quality changes are well discussed, with an especially good treatment of CA storage.

Section V, the last section, deals with processing changes, and the authors have identified and discussed some of the techniques used in flavour research. They have summarized the changes which may take place during certain processing procedures, and the mechanisms involved, for a number of aroma compounds. Changes in colour, texture and flavour are listed for several horticultural products, as related to various phases of processing operations.

This book does an excellent job of covering all phases of horticultural product quality. It has a number of good references and is highly recommended.

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FOOD SCIENCE. Second Edition. Helen Charley. John Wiley & Sons, Inc., 605 Third Avenue, New York, New York 10016, U.S.A. 1982. 564 pp. \$20.95.

Helen Charley, Professor Emeritus of Foods and Nutrition, Oregon State University, has produced a second edition of her already tried and proven work, *Food Science*. The new version incorporates new knowledge in the field in the elapsed decade and reorganizes original material for clarity and more logical presentation. It gives more emphasis to handling and cooking for safety, nutritive value and palatability.

These and other improvements, including alternate uses of world resources, make the book admirably useful and complete for classroom teaching and, additionally, as sound and informative reading for persons already working in the field. A basis of chemistry is required throughout, but the book stays within limits of practical usefulness, avoiding extremes of theory. As in the previous edition, the illustrations are excellent and well chosen.

There are a total of twenty-nine chapters ranging from sensory considerations to fundamental processes. Heating and cooling are thoroughly treated, along with market staples such as milk, meat, poultry, fish, eggs and vegetables. Water is given a particularly thorough treatment.

One enlightening aspect is the annotations to the references throughout the book, which throw considerable light on the subjects treated. The occasional light touch in the text leavens the work and makes it very readable.

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FOODBORNE AND WATERBORNE DISEASES: THEIR EPIDEMIOLOGIC CHARACTERISTICS. T.J. Tartakow and J.H. Vorperian. AVI Publishing Company, Inc., 250 Post Road East, P.O. Box 831, Westport, Connecticut 06880, U.S.A. 1981. 300 pp. \$25.00.

This book was written with the purpose of familiarizing the reader with important characteristics of foodborne and waterborne diseases, information which is vital for the prevention and control of such diseases.

The book provides a descriptive catalogue of infective agents and toxic substances which cause gastrointestinal disease or poisoning when ingested in contaminated food or water. Thirteen of the twenty-eight chapters are devoted to bacterial diseases, two to viruses and

additional single chapters to protozoa, parasites, fungi poisoning, poisonous plants, and natural food poisons. In most instances, the authors deal only superficially with the cultural characteristics and requirements of the infective agents and devote their discussion primarily to the disease itself. For each infection, the disease is characterized by giving the type of organism involved, the symptoms, the incubation period, sources of infection, prevention, laboratory diagnosis and treatment. The authors strangely enough included a rare disease like diphtheria but failed to include the *Campylobacter* species which have been involved in both waterborne and milkborne disease outbreaks in recent times.

What this reviewer found very interesting was the inclusion of epidemiological investigations of causative factors associated with a number of the foodborne diseases described. Some of the descriptions of historic epidemiologic occurrences, such as the Cholera Inquiry in Great Britain as early as 1854, make one realize that epidemiology is not a new science. Incidentally, the inquiry was known as "The Case of the Broad Street Pump" and the victims had used water from an infected well on that street. The epidemic was arrested by removal of the pump handle.

The final five chapters are on prevention of foodborne diseases, commercial food processing, food service establishments, investigation of foodborne disease outbreaks, gastrointestinal illnesses aboard cruise ships and aircraft, and finally a statistical report of foodborne and waterborne disease outbreaks.

This book provides a handy reference for information on a large number of potential food and waterborne hazards. It is presented in clear, concise terms and would be an excellent basic text for students in public health, hotel and food management, and food science. The text also would serve as a useful reference for the guidance of practicing epidemiologists, sanitarians and quality assurance personnel in the food industry.

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TRENDS IN FISH UTILIZATION. J.J. Connell and R. Hardy. Fishing News Books Ltd., 1 Long Garden Walk, Farnham, Surrey, England. 1982. 103 pp. £6.00 + 6 p post/packing.

This somewhat personalized portrayal of fish utilization in the U.K. is written by the Director and Assistant Director of the renowned Torry Research Station. The book is divided into sections on unused and under-used resources, development of conventional methods, new methods and products, and marketing of fish. Underused species (white fleshed species, Atlantic mackerel, sprat, pilchards, crabs, blue whiting, horse mackerel, oceanic species, dabs, mussels, squid, Norway pout, sandeels, argentine, various Antarctic species and filleting offal) are illustrated and briefly discussed from the U.K. viewpoint of availability and utilization.

The second section points out the problems with wastage and small or odd-shaped fish that are associated with satisfying the major market for fillets or frozen blocks. The authors discuss the prospects for expansion of conventional processing techniques such as canning and the prospects for newer methods such as minced fish; moulded, laminated, extruded, and layered products; sausages; chips, and fish protein concentrates.

The conservative nature of the fish processing industry is reflected by the statement that current techniques in other segments of the food industry are viewed as "frankly speculative." Indeed, the reader may find, as I did, that the greatest asset of this book is in providing insight into the real world problems with marketing fish. While the book is written from the perspective of the U.K. fishery, it is clearly relevant to Canadians whose industry shares many of the problems as well as future prospects outlined in the book. The treatise is, however, somewhat narrow in scope since it does not deal with the utilization of the nonflesh parts of the fish. The prospects for recovery of food, feed, biochemical, pharmaceutical and other valuable byproducts from the underused species and wastes should have also been considered, since it has an important bearing on the economics of the utilization of the flesh.

The book is lightly referenced and indexed. It will be of interest to both students and practitioners of seafood technology in Canada.

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DEVELOPMENTS IN FOOD PRESERVATION - 1. S. Thorne. Applied Science Publishers Ltd., Ripple Road, Barking IG11 0SA, Essex, England. 1981. 272 pp. \$60.00.

The publisher's stated objective in this book is to provide up to the minute reviews in the area of food preservation. Included in the avowed purpose is the intention to publish within six months of writing. While these objectives are laudable, this reviewer is unable to give very high marks to Volume 1. Very few of the articles are reviews, and one on thermal processing has but three references, one of which is an industry bulletin (albeit a good one). Generally, the articles are interesting and, for the most part, well written. Nevertheless, the majority are learned discussions by well qualified authors on their own particular view of the field and certainly not reviews.

The book is only very loosely tied together by the theme "food preservation" and for any given individual only one of the eight separate articles may be of real use. This cannot be too heavily faulted since the publisher has promised rapid publication as a basic objective for this series. In time, as the series develops, it is possible that the whole collection may be very useful as a reference. While the publishers haven't, and perhaps shouldn't, dictate to authors the nature of articles, a basic style guide should be developed. The eight articles published in Volume 1 show little consistency as to referencing, for example, and vary from a highly technical article on cooling horticultural crops (suitable for those deeply involved in the field), to an almost philosophical discussion of the needs of developing countries regarding food preservation. Some of the articles are actual reports of experiments by authors.

It should be noted that this reviewer is not disputing the validity *per se* of the articles in this book. However, as a collection of reviews on food preservation, this first volume leaves much to be desired.

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FLAVOR RESEARCH - RECENT ADVANCES. R. Teranishi, R.A. Flath and H. Sugisawa. Marcel Dekker, Inc., 270 Madison Avenue, New York, New York 10016, U.S.A. 1981. 381 pp. \$59.50.

This volume is an expanded and updated version of *Flavor Research: Principles and Techniques*, published in 1971. The present volume is the result of a Flavor Workshop held just prior to the American Chemical Society Annual Meeting held in Hawaii in 1980 jointly with the Chemical Society of Japan, the Royal Australian Chemical Institute and the New Zealand Institute of Chemistry. Two of the editors (Drs. Teranishi and Flath) are with the Berkeley Laboratory of the United States Department of Agriculture and are members of a group that have been leaders in flavor chemistry research for over two decades. Professor Sugisawa is a member of the Department of Food Science of Kajawa, University of Japan.

The first chapter, by Flath, Sugisawa and Teranishi, is a very brief (10 pages) summary of the classical problems of odor sensitivity, diversity, complexity, instability and evaluation. The second chapter, by Sugisawa, is an excellent review of the methodology for the isolation and concentration of volatiles. In the third chapter, Teranishi further reviews separations via distillation and liquid and gas chromatography, with major emphasis on the latter. Flath reviews methods of identification (mass spectrometry, nuclear magnetic resonance and infrared spectroscopy) in the fourth chapter. Sensory characterization is reviewed by Forss in Chapter 5. Buttery presents a comprehensive review of fruit and vegetable flavors in the sixth chapter. In Chapter 7 Katz presents a short review on meat flavor chemistry. Yamanishi reviews in Chapter 8 the chemistry of aromas of tea, coffee, cocoa and roasted barley (mugi-cha). Kuninaka departs from aromas to review flavor (taste) enhancers in Chapter 9. In Chapter 10, there are brief reviews by Forss on the flavor of dairy products and by Sugisawa on soy sauce and soy paste.

The book is well done and generally achieves the stated objectives of the editors in pointing out accomplishments in selected areas of flavor research since 1970. Most of the chapter authors have themselves been active in flavor research for many years.

Although most of the references cited were published since 1970, very few of these are more recent than 1976, thus, in the areas covered, one may have to look to other sources for more recent reviews.

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NEW PROTEIN FOODS. Volume 4. ANIMAL PROTEIN SUPPLIES, Part B. Aaron M. Altschul and Harold L. Wilcke. Academic Press, Inc., 111 Fifth Avenue, New York, New York 10003, U.S.A. 1981. 378 pp. \$49.00.

Prefaces to books are often obviously written as duties to conformity. The preface to this one, however, contains an essay on "the flexibility inherent in new knowledge and technology," and is well worth the reader's attention as an overview of both the content of the book and the nutritional and historical philosophy within which animal protein supplies may be considered.

The problems addressed include a wide range, from the economic and social factors involved in livestock production to new options for food that might be acceptable to a highly sophisticated technological society, from the utilization of two billion tons of animal wastes produced annually in the United States to amino acid fortification of dietary protein, from the efficiency of production of swine, poultry and small ruminants to microorganisms as feed and food protein (single cell protein). To address these varied topics, and to bring diverse points of view to them, the contributors to the volume are from international agencies, from the United States Department of Agriculture, and from university departments of food science and nutrition, animal science, economics, community and family medicine, and epidemiology and public health.

The book is interesting reading for the food technologist, the nutritionist and the general agricultural scientist. It can be recommended for its breadth of approach to students at all levels in many disciplines and should be on the supplementary reading list for many university courses.

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SOURCE BOOK OF FOOD ENZYMOLOGY. S. Schwimmer. AVI Publishing Company, Inc., 250 Post Road East, P.O. Box 831, Westport, Connecticut 06880, U.S.A. 1981. 967 pp. \$85.00 U.S.; \$93.50 other countries.

"Overwhelming" is one's first thought on leafing through the roughly 1,000 page food enzymology text authored by Sigmund Schwimmer. One's second thought is the pleasure of seeing a comprehensive book covering enzymology specifically from a food scientist's viewpoint, such treatises having been extremely limited in the past.

The text is divided into ten parts:

- I Perspectives and Prospectus
- II Basics of Enzymology
- III Enzyme Production and Related Topics
- IV Nonbiological Control and Management of Enzyme Action
- V Enzyme Action and Food Color Quality
- VI Enzyme Action and Food Flavor Quality
- VII Enzyme Action and the Textural Quality of Foods
- VIII Enzyme Action and Food Transformations: Change-of-State, Appearance and Identity
- IX Enzyme Action in Protein Modification and Health-Associated Aspects of Food Quality
- X Enzyme Action in the Quality Control Laboratory - Assay, Testing, Analysis

Each part comprises three to six chapters addressing general subjects under the main headings, which in turn are further subdivided into specific topics. The book contains an extensive bibliography (146 pages), a good general subject index and a separate enzyme index.

It is very well written and easy to read, containing a balanced amount of well chosen illustrations and tabulated data.

As part of the AVI Sourcebook and Handbook Series, Schwimmer's book is unique in that it can serve the function of being an information source, and yet is readable and organized in a textbook fashion. I would strongly recommend this book for all food science libraries, and more specifically it would be an ideal text or reference for any graduate course dealing with food enzymes.

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SANITARY TECHNIQUES IN FOODSERVICE. Second Edition. Karla Longrée and Gertrude G. Blaker. John Wiley & Sons, Inc., 605 Third Avenue, New York, New York 10016, U.S.A. 1982. 271 pp. \$15.50.

The second edition of *Sanitary Techniques in Foodservice* is an updated and much expanded version of the first edition published in 1971. New material has been included on food preparation in institutions, new pieces of equipment, changes in food supply and in microbiological problems facing foodservices.

The second edition continues the same general format as the first, that is, dividing the material into four major parts: (1) Food Sanitation and Microbiology; (2) Food Spoilage and Foodborne Illnesses; (3) Sanitary Practice; and (4) Education and Training in Sanitation of Foodservice Personnel. Each part contains several sections and each of these uses many subheadings. The material is presented in a logical sequence and is easy to follow, and the book can readily be used as a reference for specific points. At the end of each part there is a summary of the important facts that need to be emphasized. Study questions are also included, as is a list of reference readings for those who want to pursue the topics in more detail.

Drs. Longrée and Blaker are very knowledgeable in the area of sanitation. They write from a wealth of experience, in language that is clear and can be understood by foodservice personnel who may not have a strong physical science background. Use of figures, illustrations and a list of definitions enhances the material.

The major thrust of this book is the practical "how to" approach to sanitation. The third part deals with cleaning facilities and equipment; purchasing food and storing it safely; food production, holding, refrigeration and use of leftovers; personal hygiene and work habits. Practical, procedural information is provided on these topics in some detail. References to temperatures are given in fahrenheit and celsius. All references to government agencies, laws and regulations are, understandably, American.

The disappointing section, to me, was the last one, on training personnel in sanitation. The topic is covered in four pages and essentially reviews the process of on the job training. Nevertheless, *Sanitary Techniques in Foodservice* will continue to be an excellent reference for practitioners and a very fundamental text for students in technical level programs.

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PROTEIN FOOD SUPPLEMENTS. M. A. Maltz. Noyes Data Corporation, Mill Road at Grand Avenue, Park Ridge, New Jersey 07656, U.S.A. 1981. 404 pp. \$48.00.

This book is entirely similar to those preceding it in this series, being a compilation of recent (1974 onwards) U.S. patent abstracts dealing with food proteins. Subjects include single cell protein materials, soybean protein processing, proteins isolated from other seeds, grains and leafy plants, protein products of dairy origin, of animal origin, and a final chapter describing miscellaneous applications. As might be expected, the inventions described differ considerably in their applicability, novelty and ultimate usefulness, varying from the bare extension of previous knowledge to a different species, through the disclosure of an entirely new concept, such as the Canadian process described for preparing undenatured, functional protein isolates via the formation of protein micelles. In any case, those food scientists requiring a collection of recent food protein literature will find this volume as useful as its first edition, which the present work updates.

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QUANTITY FOOD SANITATION. Third Edition. Karla Longrée. John Wiley & Sons, Inc., One Wiley Drive, Somerset, New Jersey 08873, U.S.A. 1980. 456 pp. \$27.50.

Dr. Longrée's *Quantity Food Sanitation* is concisely written yet comprehensive in its coverage of the subject. Foodservice managers, college faculty and students, public health officials, dietitians and professionals in related fields can rely on this authoritative text for thorough, reliable, current, well organized information. The recommendations given for handling food safely are in accordance with those of the United States Department of Health, Education and Welfare.

Effectively interrelated are the numerous areas of concern such

as microbiology, epidemiological data, effects of various food processing methods, etc. Special attention is given to the time-temperature relationships which are so critical in assuring safe food production, service and storage.

References cited at the end of each chapter include several of Longrée's research articles, further testifying to her thorough expertise in this field.

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A COMPLETE COURSE IN CANNING. Eleventh Edition. A. Lopez. The Canning Trade, Inc., 2619 Maryland Avenue, Baltimore, Maryland 21218, U.S.A. Book I: BASIC INFORMATION ON CANNING. 1981. 556 pp. Book II: PROCESSING PROCEDURES FOR CANNED FOOD PRODUCTS. 1981. 473 pp. \$50.00 each or \$90.00 for the set (both books).

The eleventh edition of *A Complete Course in Canning* has been updated and the overall format has been changed from previous editions. This new edition is presented in two parts: Book I and Book II.

Book I, 556 pages, is divided into seventeen chapters, a glossary of terms, buyer's guide and subject index. It contains the basic information that applies to the canning of food. Book II, 473 pages, is divided into twelve chapters, an appendix, glossary of terms, buyer's guide and subject index. It contains processing procedures for canned food products and includes specific information on canning of over 210 products.

As the title suggests, the book is intended as a source of information on canned foods and canning technology as a whole. The reader will find experimental data on all facets of canned foods including product formulae, manufacturing procedures, food laws, sanitation, sterilization, spoilage, containers, food plant characteristics and warehousing, to name a few.

The newly added sections to this edition are "Heat Penetration Determinations and Thermal Process Calculations," "The Retort Pouch," "Canned Salads," "Manufacture of Canned Baby Foods" and an appendix with pertinent information.

The new section on heat penetration determination and thermal process calculations is very well written and has sufficient illustrations to make the concept understandable to the reader. The retort pouch has also been well discussed, starting with its history and ending with the advantages and disadvantages of the retort pouch.

In Book I, the section on food laws and regulations, ingredients, food plant sanitation, sterilization systems and energy usage in canning operations, have been revised and expanded considerably. Furthermore, in Book II the processing methods and directions given on canning of products have been brought up to date.

In summary, this new edition is specifically industry oriented, and not generally suitable for educational institutions involved in teaching food science. However, the books are comprehensive enough to be used as handbooks in the canning industry.

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REVIEW

Precipitation and Recovery of Whey Proteins: A Review

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Abstract

The economic feasibility of recovering whey protein is dependent upon the efficiency of the process and the utilization of the protein isolate. Heat processing is an efficient method of recovering whey proteins which can be used in process cheese spreads. Chemical precipitation of whey proteins yields functional isolates which promote gelation, whipping and emulsification, but residual precipitants are retained. Co-precipitation of casein and whey protein as occurs in the manufacture of Queso Blanco is the simplest method of recovering whey proteins. Membrane processing offers great potential for whey protein recovery. Required conditions and selected processes for the precipitation and recovery of whey proteins are discussed.

Résumé

La rentabilité de la récupération des protéines de lactosérum dépend de l'efficacité du procédé utilisé et de l'usage que l'on fait de l'isolat protéique. Le traitement à la chaleur est une méthode efficace de récupération des protéines de lactosérum lorsque celles-ci sont destinées à la fabrication du fromage fondu. La précipitation chimique des protéines de lactosérum donne des isolats aux propriétés fonctionnelles propices à la formation de gel, au fouettement et à l'émulsification, mais a l'inconvénient de laisser des résidus chimiques. La co-précipitation de la caséine et des protéines de lactosérum comme au cours de la fabrication du fromage Queso Blanco est la méthode la plus simple pour récupérer les protéines de lactosérum. Les procédés à membrane offre aussi de grandes possibilités pour la récupération des protéines de lactosérum. On discute des conditions requises et de certains procédés pour la précipitation et la récupération des protéines de lactosérum.

Introduction

There are numerous commercial, proprietary and experimental procedures for the recovery of whey protein as whey concentrates (e.g., whey powder), whey protein concentrates and co-precipitates. The principles and the commercial feasibility of some of these processes will be discussed. Special attention will be given to heat processing.

Heat Precipitation of Proteins

The concept of protein denaturation is sometimes confused with protein aggregation or coagulation. Conditions which promote protein denaturation do not necessarily

encourage protein aggregation. This was demonstrated by Rowland (1933) but failure to recognize this concept is still causing confusion. The literature on whey protein denaturation has been reviewed (McKenzie, 1971; Lyster, 1972). The aggregation of whey proteins by heat, heat-acid, urea or alkali is preceded by denaturation and may be followed by coagulation and precipitation. The literature concerning the mechanism of denaturation and aggregation of β -lactoglobulin has been reviewed by Sawyer (1969) and McKenzie (1971). Heat-denatured whey proteins are structurally altered to expose sulphide groups. These structural changes are rapid at pHs greater than 6.7 and temperatures greater than 70°C (Lyster, 1972). Sawyer (1968) demonstrated that aggregation follows primary and secondary reactions, and described the reaction products as follows. The primary products are colloidal aggregates formed by SH/SS interchange at temperatures greater than 70°C, while the secondary reaction, which is favoured at 60-70°C, yields larger colloidal structures formed by nonspecific aggregation of the primary products. The secondary reaction is not dependent on SS bonding and its products may undergo further nonspecific aggregation, yielding a precipitable coagulum. Another type of nonspecific primary aggregation takes place if SH groups are blocked by N-ethylmaleimide, but this pathway results in lower yields of secondary products. The gross aggregation (coagulation) of secondary products occurs in the presence of calcium (Kenkare *et al.*, 1964; Koyama *et al.*, 1964; Morr and Josephson, 1968) and is favoured by pH in the isoelectric region of the proteins (Zittle and Dellamonica, 1956; Richert *et al.*, 1974). Hence the term "heat-acid precipitation," meaning that heat-denatured colloidal proteins are destabilized by the addition of acid in the presence of calcium. Isoelectric precipitation may also be induced by addition of calcium, but cheese ash content is increased and bitterness may result. Generally, the recovery of protein and the composition of heat-precipitated whey protein (HPWP) depend on pH, temperature and ionic strength. The optimum pH depends on

the type of whey and is probably related to the initial pH and calcium content of the whey. Robinson *et al.* (1976) obtained maximum protein precipitation from sweet whey (high pH, low calcium) by acidifying to pH 4.5 before heating, and from acid whey (low pH, high calcium) by neutralizing to pH 6.5 with sodium hydroxide before heat treatment. The time of acidification (before or after heating) is also important. It is believed that protein recovery from sweet whey is maximized by heat denaturation at about pH 6.5, followed by acidification and/or addition of calcium to induce gross aggregation. In the case of acid whey, neutralization before heating aids protein denaturation, but the ionic conditions are such that subsequent acidification does not affect the aggregation process except to lower the HPWP ash content (Panzer *et al.*, 1976). Hidalgo and Gamper (1977) studied the precipitation of proteins from ultrafiltered whey retentate. In the absence of calcium chloride, maximum precipitation of protein was induced by heating at pHs of 6.6-6.9, cooling to room temperature and adjustment of pH to the isoelectric zone. In the presence of 0.03 M CaCl₂ the aggregation of whey protein after heating and cooling was independent of pH over the pH range of 2-12. The interaction effects of pH and ionic strength may account for the different acid and heat treatments which have been recommended for the recovery of proteins from whey. In addition, the mechanics of processing are also important. For example, Hill *et al.* (1982a) reported that under laboratory conditions maximum protein recovery was obtained from sweet whey by heating without adding acid. However, in the pilot plant, acid addition after heating was required in order to induce the formation of larger curd particles and to facilitate separation by filtration on wire screen.

The theoretical maximum recovery of crude protein (total nitrogen x 6.4) from whey is 55-65% because the heat stable proteose-peptone fraction and nonprotein nitrogen (NPN) constitutes 35-45% of whey nitrogen (Larson and Roller, 1955; Cerbulis and Farrell, 1975). Commercially feasible processes should recover at least 50% of the crude protein. Some processes for separating whey proteins are described below.

Heat-Precipitated Whey Protein

Ricotta Cheese. Ricotta cheese and casein-whey HPWP are the two main products which utilize HPWP. Traditionally ricotta cheese is made from sweet whey of pH 6.3 or higher. A suitable product for table use is produced by heating (80-90°C) without adding acid, and then skimming the floating curd from the surface. Subsequently, a second "rise" of curd is obtained by acidifying the partially deproteinized whey to pH 5.0-5.5. This curd is coarse, grainy, darker in colour and is normally used as a food ingredient. Ricotta manufacture is labour and energy inefficient because heating takes place in small, open vats and the curd is skimmed by hand. Yields are low owing to incomplete recovery of precipitate. Streiff *et al.* (1979) reported a modified process for the manufacture of traditional ricotta cheese. Whey was condensed up to 30% solids by vacuum evaporation and the pH standardized to 6.5. Condensed whey was then processed by heating it to 44°C, adding 0.8% NaCl, heating to 88°C, and adjusting

pH to 4.8-5.0, followed by filtration. Acceptable ricotta cheese was produced from condensed whey of up to 21% solids. Yields ranged from 5.3% for whole whey to 21.3% for whey of 21.9% solids. The lowest protein recovery was 59.1% from whey of about 20% solids. This result is in agreement with the work of Guy *et al.* (1967) and Nielson *et al.* (1973) who reported that whey proteins were most stable to heat denaturation in concentrates of about 20% solids. The process of Streiff *et al.* (1979) has advantages compared to traditional methods: hand skimming is avoided, heating takes place in closed vats and essentially all coagulated protein is recovered.

Casein-Whey HPWP. The manufacture of ripened cheese results in sweet whey (pH 5.9-6.5) while the manufacture of casein and fresh cheese (such as cottage cheese, quarg and cream cheese) results in acid whey (pH 4.4-4.8). Developments in the manufacture of HPWP from casein whey in New Zealand have been reviewed by Mann (1977). Dried HPWP (often called insoluble lactalbumin) is used for nonfunctional purposes such as protein fortification of pasta and cereal products. Robinson *et al.* (1976) reviewed the heating and pH conditions which have been proposed to maximize yields of HPWP from casein whey. They found that conditions for maximum precipitation of protein from casein whey included heating at 93°C and pH 6.5 for 12 min. Laboratory yields of heat-coagulable protein, with and without neutralization, were 90% and 75%, respectively. Normally, HPWP is manufactured at the pH of casein whey (4.4-4.6) because the ash content of HPWP is minimized by separation in the isoelectric region. The New Zealand commercial process, using regenerative heating and centrifugation, yields HPWP containing 80-90% protein, 0.9-7.0% lactose, 0.5-4.0% ash and 1.0-6.0% fat on dry basis (db) (Robinson *et al.*, 1976).

Acid-Whey HPWP. Cogan *et al.* (1978) studied the use of acid whey for the manufacture of HPWP. In agreement with Robinson *et al.* (1976), they obtained maximum yields by neutralization before heating. The fresh HPWP was successfully incorporated at levels up to 20% in quarg. Al-Dabbagh (1980) investigated the use of fresh HPWP in sandwich spreads. The use of fresh HPWP exploits the high water-binding capacity of heat-denatured whey proteins. Fresh HPWP binds 6-7 g water/g protein while dried HPWP has the ability to bind only 1-1.8 g water/g protein (Jelen *et al.*, 1979).

Panzer *et al.* (1976) described a continuous process for recovering cottage cheese whey HPWP involving neutralization to pH 6.0, heating at 120°C and an optional reacidification to pH 4.6. Reacidification decreased the ash content of the HPWP from about 23% to less than 5%. Ash was further reduced to 2% by washing the precipitate with water.

Effect of Concentrating Sweet Whey. The manufacture of HPWP from sweet whey has been restricted to the traditional ricotta cheese. Recently the use of concentrated sweet whey to prepare HPWP for use as a food ingredient (similar to casein- or acid-whey HPWP) has been reported. Hill *et al.* (1982a) precipitated proteins from sweet whey concentrated by reverse osmosis (RO). The pH was about

6.5 before concentration and 6.3 after concentration to 20% solids. About 90% of the coagulable proteins were recovered by heating to 95°C for 5 min and acidifying to pH 5.5. Ash content decreased with the pH of precipitation, in agreement with the data of Robinson *et al.* (1976). Moisture content ranged from 54-70% and showed a pronounced minimum in the isoelectric zone. A typical composition was 70% moisture, 25% protein, 3.5% ash and 2% fat. The fresh HPWP was used to replace all or part of cheese in process cheese spreads (Irvine *et al.*, 1982).

Modler and Emmons (1977) obtained 85-97% recovery of protein nitrogen from condensed whey (17.5% solids) by acidifying to pH 2.5 and heating to 95°C. However, when single strength whey was subjected to the same process, little or no precipitation occurred. Kuipers (1975) also reported that single strength whey may be acidified to pH 2.7-3.3 and subsequently heat sterilized without precipitating the whey protein. Shulkamy and Monib (1976) obtained maximum precipitation of protein from sweet whey by acidifying to pH 3.5 and heating to 95°C for 20 min. This result apparently disagrees with that of Kuipers (1975).

Effect of Iron. Modler and Emmons (1977) further reported an effect of iron on protein recovery from whey. Single strength sweet whey yielded 24% recovery of protein nitrogen when acidified to pH 3.5 and heated at 95°C. When iron was added (0.00018 M) to the whey, the same process yielded 46% of protein nitrogen. When the same two samples were subsequently adjusted to pH 4.5 after cooling, more precipitation occurred and the total protein recovery from single strength whey, with and without iron addition, was 71 and 75%, respectively. Amantea *et al.* (1974) also studied the use of iron to precipitate proteins from whey at pH 2.5 and found that maximum yields were obtained without subsequent pH adjustment. Although the feasibility of using iron is uncertain, the solubility studies of both Amantea *et al.* (1974) and Modler and Emmons (1977) indicated that HPWP produced by acidification followed by heating may have greater solubility than that produced by heating followed by acidification.

Summary. The present knowledge of protein separation from whey by heat processing can be summarized as follows. Maximum protein recovery is obtained by denaturing whey proteins at pHs in the range 6.0-7.0 and at temperatures greater than 90°C for 10-30 min, followed by precipitation at pHs of 4.4-5.0. The pH dependence of whey protein aggregation is decreased in the presence of calcium. The ash content of HPWP is increased by neutralizing the whey, and minimized by precipitation at low pH (3.5-4.6). Denaturation and precipitation at low pH maximize HPWP solubility. The theoretical maximum recovery of nitrogen is 55-65% and a commercial process should recover at least 50%.

Co-Precipitates

Whey proteins may be co-precipitated with casein or with other proteins such as blood, egg and soya proteins (Richert, 1975). Casein-whey protein co-precipitates have been reviewed (Richert, 1975; Southward and Goldman, 1975). The β -lactoglobulin/ κ -casein complex which prob-

ably causes co-precipitation has been reviewed (Sawyer, 1969). When whey proteins are denatured in the presence of casein, exposed sulphydryl groups react preferentially with casein (Trautman and Swanson, 1958; Rose, 1962; Zittle *et al.*, 1962; Sawyer *et al.*, 1963; Kenkare *et al.*, 1964; Creamer *et al.*, 1978). Therefore, whey proteins are stabilized against heat precipitation by casein (Rowland, 1933; Ramsdell and Whittier, 1953). Although casein may decrease the rate of denaturation of β -lactoglobulin (Hillier and Lyster, 1979), the stabilizing effect of casein is mainly due to the blockage of whey protein primary aggregation. Co-precipitation can be induced by acidification but maximum yield is obtained when acid is added in conjunction with low levels of calcium chloride (Mathur and Shahani, 1977; Hill *et al.*, 1982b).

Although a process for the co-precipitation of milk proteins was patented in 1952 (Southward and Goldman, 1975), varieties of cheese native to Mexico, Latin America, Egypt and India have been manufactured by similar processes – probably for many centuries. The manufacture, composition and utilization of these fresh cheese types, known as Queso Blanco in Latin America and as Chhana or Paneer in India, have been reviewed (Torres and Chandan, 1981). Hill *et al.* (1982b) defined the processing parameters for the traditional manufacture of Queso Blanco. Acceptable cheese was made from milk or recombined milk of 10-15% solids-not-fat (SNF) and 3.0-4.5% fat. Milk was heated at 82°C for 10 min, followed by the addition of citric acid, to give a cheese pH of about 5.2. An equation was developed to predict the required amount of citric acid from the protein content of the milk supply.

The manufacture of ricotta type cheese from blends of whey and milk or milk solids also involves co-precipitation. Shahani (1979) reported that whey protein recovery (excluding NPN) increased from 30.6% for sweet whey to 64.4% and 70.0% for blends of whole milk and whey (25:75), and skim solids and whey (2:98), respectively. The curd was flocculated at pH 6.8 with heat and calcium chloride.

It is believed that Queso Blanco and ricotta type cheese have potential to replace cheese in the manufacture of process cheese and process cheese spreads. The advantages would be increased utilization of whey protein, and reduced processing time and equipment requirements owing to the rapid make procedure. In addition, Queso Blanco type cheese has potential as a table cheese in Canada and the United States (Chandan *et al.*, 1979).

Whey-blood co-precipitate is a poor protein source because the heat treatment required to destabilize whey proteins causes large decreases in the protein efficiency ratio and biological value of the blood protein (Young, 1980). However, heat treatment does not alter the nutritional quality of whey protein (Forsum and Hambraeus, 1977). In the case of egg-whey protein co-precipitate, the heat treatment required to destabilize whey proteins destroys the functionality of the egg albumin (Stadelman and Cotterill, 1973). Plant-whey protein co-precipitates prepared by acid-heat processing also showed reduced functionality (Thompson, 1977; Morr, 1978). These problems do not preclude the use of chemical precipitants for egg-, blood-, or plant-whey systems, or the use of blended protein isolates (Schmidt and Illingworth, 1978).

Chemical Precipitants

The separation of whey proteins which retain native properties (solubility and the ability to gel, whip and emulsify) requires the use of chemical precipitants and/or membrane processing (Morr, 1978). Chemical precipitants which have been reported include polyphosphates, carboxymethylcellulose (CMC), polyacrylic acid and alcohols. Hartman and Swanson (1966) recovered practically all whey proteins from whey at pH 2.5 with 0.5% sodium hexametaphosphate (HMP). Hidalgo *et al.* (1973) obtained 90% recovery of protein nitrogen by acidifying to pH 3.0 and adding 0.1 and 0.7% HMP to acid and sweet whey, respectively. Protein recovery was improved by demineralization prior to precipitation and the residual HMP was reduced by ion exchange or gel filtration. The final product showed some native properties and contained only 9.9% residual HMP, 88.3% protein and 1.8% lactose. However, the process was too costly and complex for general implementation in the cheese industry. A simplified process for protein-phosphate precipitation has been described (Gillies, 1974). The product, containing 40-70% protein and 12-25% phosphate, was blended with demineralized whey powder and used as a replacement for sodium caseinate. Jones *et al.* (1972) described a lengthy process using ferripolyphosphate to precipitate whey proteins. The process recovered 95% of protein nitrogen but the isolate contained 39% phosphate and 5% calcium. Whey protein-phosphates have good emulsifying ability but poor solubility and poor whippability at pH 4.6 (Morr *et al.*, 1973).

CMC precipitation has been used commercially to recover proteins from whey (Robinson and Tamine, 1978). Hidalgo and Hansen (1969) demonstrated that negatively charged anionic hydrocolloids such as CMC, carrageenan or sulphated cellulose form ionic complexes with β -lactoglobulin which can be isolated from solution by isoelectric precipitation. The reaction with CMC was sensitive to pH and ionic strength, and if more than stoichiometric amounts of CMC were added, peptization of the protein occurred. Hansen *et al.* (1971) used CMC to obtain an acidic fraction (precipitated at pH 3.2) containing more than 90% of the whey protein nitrogen, and subsequently an alkaline fraction (precipitated at pH 7.5-8.0) containing most of the proteose peptone. The second fraction was not usable because it contained 54% ash (db). The first fraction contained 30% CMC, 63% protein and 1.5% ash. They also reported that the isolate formed stable emulsions over a wide pH range and showed good whipping properties. The process was simple, involving addition of hydrochloric acid and CMC solution, followed by centrifugation or filtration.

Cerbulis (1978) investigated the use of bentonite (aluminum silicate) and lignosulphonate to precipitate proteins from cottage cheese whey. When used singly or in combination, these colloids precipitated practically all protein nitrogen. The process involved only a single step because the precipitation was at the pH of cottage cheese whey (acidification to pH 2-3 is required for CMC or HMP precipitation). However, the utility of the precipitates is uncertain due to high residual precipitants. The anionic hydrocolloid chitosan (a derivative of chitin) has also been used experimentally to precipitate whey protein (Wa *et al.*, 1978).

The separation of proteins with polyacrylic acids was investigated by Sternberg and Hershberger (1974) who were able to selectively precipitate various proteins. Sternberg *et al.* (1976) used polyacrylic acid to prepare a whey protein isolate suitable to replace egg white. Whey was acidified and mixed with filter aid (presumably siliceous earth) and polyacrylic acid. After settling and decanting, the solids were vacuum filtered, resuspended in water, neutralized with magnesium or calcium carbonate and refiltered. The filtrate containing the protein was concentrated under vacuum to 20% solids and freeze-dried, while the cake containing filter aid and magnesium polyacrylate was resuspended in water, acidified and recycled. The process yielded a functional isolate, free of precipitant, but involved fourteen separate steps including costly vacuum concentration and freeze-drying.

Whey proteins have also been precipitated with alcohols (ethanol was preferred), but the precipitate contained 22-34% ash and only 34-46% of whey nitrogen was recovered (Morr and Lin, 1970). Forsum and Hambraeus (1977) reported that alcohol precipitation reduced the biological value of whey protein.

Membrane Processing

Reverse Osmosis

The terms "reverse osmosis" and "ultrafiltration" are often confused. The characteristic of an RO membrane is that both its chemical nature and porous structure govern solute separation (Sourirajan, 1977). Sourirajan (1977) further states that the process which is often called ultrafiltration (UF) is also partly determined by the chemical nature of the membrane and is not adequately described by sieve filtration. Any distinction between RO and UF on the basis of pore size is therefore arbitrary. The distinction is especially difficult when membranes of intermediate rejection characteristics are considered. This discussion, therefore, makes no distinction between RO and UF. UF membranes are considered to be RO membranes with different solute rejection characteristics. Working definitions for specific membranes are given with respect to percentage salt (NaCl) rejection.

The composition of whey concentrated by RO depends on the rejection characteristics of the membrane, the amount of water removed and operating conditions. The retention of lactose and minerals is affected by flow rate, turbulence and feed pressure, but the relationships are not simple (Peri and Dunkley, 1971a,b; Roualeyn *et al.*, 1971). RO membranes of 75, 91 and 95% salt rejection retain 97.0, 98.3 and 99.0% of total whey solids, respectively (McDonough and Mattingly, 1970). Losses were mainly minerals, NPN, lactose and lactic acid. The loss of minerals from a 75% salt rejection membrane was about 25% (McDonough and Mattingly, 1970). Calcium and phosphorus do not readily pass through RO membranes, and cause membrane fouling (Smith and MacBean, 1978; Lawrence and Harper, 1979; Hiddink *et al.*, 1980). Potassium and chloride ions and lactic acid are more readily lost in the permeate (Peri and Dunkley, 1971a). Practical limits of concentration are about 20% total solids (70% water removal) for 75-95% salt rejection membranes (McDonough and Mattingly, 1970; Stirland, 1978; Workshop Discussion, 1978) and about 17% total solids or 90% water removal (retentate containing about

5% protein) for zero salt rejection membranes (Sarma and Batty, 1979). Intermediate salt rejection membranes and/or secondary fractionation may be used to give desired compositions (Marschall, 1978). Maubois (1980) reported the use of RO membranes (salt rejection unspecified but presumably low) to produce an α -lactalbumin-rich protein concentrate, which was demineralized and used in infant formulations to simulate breast milk. Maubois (1980) further reported the development of a new low salt rejection membrane which can be heat sterilized. Made from zirconium oxide and supported by graphite, this new membrane is resistant to any pH and temperatures up to 400°C.

Whey concentration by RO has many advantages: energy requirements are low, cost of transporting whey to central processing facilities is reduced (Muller, 1978), cost of preconcentration before spray dehydration, protein precipitation, gel filtration or electrodialysis is reduced, and the protein concentrate retains functional properties (Morr *et al.*, 1973). One Canadian company has concentrated 45,000 kg of whey/day to 20% solids at a cost of \$500, including all fixed and operating costs and the cost of pasteurization (J. Duckworth, personal communication).

The principles and interrelationships of RO and gel filtration have been discussed (O'Sullivan, 1971). Gel filtration following concentration by evaporation or RO to 20% solids and partial lactose crystallization yielded a product of about 50% protein, 35% lactose and 10% ash (Richert, 1975).

Electrodialysis

Electrodialysis was used commercially in the United States to demineralize concentrated whey in 1961 (Zang, 1966). Typically, demineralization follows concentration and partial lactose removal and yields a product of 35% protein, 50% lactose and 10% ash (Richert, 1975). Sodium, potassium and chloride ions are easily removed by electrodialysis and the residual ash contains most of the calcium, magnesium and phosphorus. Electrodialyzed whey has been used in infant formulations, but the most important commercial application is for the preparation of simulated skim milk (Richert, 1975).

Ion Exchange

Where high percentage ash removal is required, as for infant formulations, resin ion exchange columns are more efficient and economical than electrodialysis with respect to fixed and operating costs, including waste management (Houldsworth, 1980). Ion exchange is also being used commercially to isolate proteins from sweet or acid wheys (Morris, 1981). The costs of the process are comparable to the costs of protein separation by RO. Protein recovery is practically complete and the isolate contains 90% protein. Developments in ion exchange and other fractionation processes have been reviewed (Marschall, 1978).

Conclusion

Precipitation by heat processing remains the simplest method to recover proteins from sweet and acid wheys. This fresh undried HPWP has the potential to replace all or part of cheese in process cheese spreads. There is a need to investigate the manufacture and utilization of

casein-whey protein co-precipitates. Chemical precipitants are useful for the recovery of functional proteins and maximize protein recovery from acid wheys. However, utilization is limited because commercial procedures for the removal of precipitants are not yet available. Protein concentrates prepared with CMC may have potential as a base for spreads, dips and whipped products. Whey protein-phosphates may be used in spreads and dips or as a substitute for sodium caseinate. There is also great potential for whey processing development using RO and ion exchange processes.

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References

- Al-Dabbagh, F.B. 1980. Utilization of heat precipitated whey protein. *Food Sci. Technol. Abstr.* 12(2)2P245.
- Amantea, G.F., Kason, C.M., Nakai, S., Bragg, D.B. and Emmons, D.B. 1974. Preparation of ferric whey protein by heating. *Can. Inst. Food Sci. Technol. J.* 7:199.
- Cerbulis, J. and Farrell, H.M., Jr. 1975. Composition of milks of dairy cattle. I. Protein, lactose and fat contents, and distribution of protein fraction. *J. Dairy Sci.* 58:817.
- Cerbulis, J. 1978. Precipitation of proteins from whey with bentonite and lignosulfonate. *J. Agric. Food Chem.* 26:806.
- Chandan, R.C., Marin, H., Nakrani, K.R. and Zehner, M.D. 1979. Production and consumer acceptance of Latin American white cheese. *J. Dairy Sci.* 62:691.
- Cogan, U., Weiss, J., Calmanovici, B., Graff, J. and Gur-ari, G. 1978. Recovery of whey proteins and their utilization in dairy products. XX Int. Dairy Congress. Volume E. Page 930.
- Creamer, L.K., Berry, G.P. and Matheson, A.R. 1978. The effect of pH on protein aggregation in heated skim milk. *N.Z.J. Dairy Sci. Technol.* 13:9.
- Forsum, E. and Hambræus, L. 1977. Nutritional and biochemical studies of whey products. *J. Dairy Sci.* 60:370.
- Gillies, M.T. 1974. Whey Processing and Utilization. Noyes Data Corporation, Park Ridge, NJ. Page 160.
- Guy, E.J., Vettel, H.E. and Pallansch, M.J. 1967. Denaturation of cottage cheese whey proteins by heat. *J. Dairy Sci.* 50:828.
- Hansen, P.M.T., Hidalgo, J. and Gould, I.A. 1971. Reclamation of whey protein with carboxymethylcellulose. *J. Dairy Sci.* 54:830.
- Hartman, G.H. and Swanson, A.M. 1966. Precipitation of protein from cheese whey with polyphosphates. *J. Dairy Sci.* 49:697.
- Hidalgo, J. and Hansen, P.M.T. 1969. Interactions between food stabilizers and β -lactoglobulin. *J. Agric. Food Chem.* 17:1089.
- Hidalgo, J., Kruseman, J. and Bohren, H.U. 1973. Recovery of whey proteins with sodium hexametaphosphate. *J. Dairy Sci.* 56:989.
- Hidalgo, J. and Gamper, E. 1977. Solubility and heat stability of whey protein concentrates. *J. Dairy Sci.* 60:1515.
- Hiddink, J., deBoer, R. and Nooy, P.F.C. 1980. Reverse osmosis of dairy liquids. *J. Dairy Sci.* 63:204.
- Hill, A.R., Bullock, D.H. and Irvine, D.M. 1982a. Recovery of whey proteins from concentrated sweet whey. *Can. Inst. Food Sci. Technol. J.* 15:180.
- Hill, A.R., Bullock, D.H. and Irvine, D.M. 1982b. Manufacturing parameters of Queso Blanco made from milk and recombined milk. *Can. Inst. Food Sci. Technol. J.* 15:47.
- Hillier, R.M. and Lyster, R.L.J. 1979. Whey protein denaturation in heated milk and cheese whey. *J. Dairy Res.* 46:95.
- Houldsworth, D.W. 1980. Demineralization of whey by means of ion exchange and electrodialysis. *J. Soc. Dairy Technol.* 33:45.
- Irvine, D.M., Bullock, D.H. and Hill, A.R. 1982. Utilization of sweet whey lactalbumin in cheese spread. XXI Int. Dairy Congress (In press).
- Jelen, P., Kalab, M. and Greig, R.I.W. 1979. Waterholding capacity and microstructure of heat coagulated whey protein powders. *Milchwissenschaft* 34:351.
- Jones, S.B., Kalan, E.B., Jones, T.C. and Hazel, J.F. 1972. Ferripoly-

- phosphate as a whey protein precipitant. *J. Agric. Food Chem.* 20:229.
- Kenkare, D.B., Morr, C.V. and Gould, I.A. 1964. Factors affecting the heat aggregation of proteins in selected skim milk sera. *J. Dairy Sci.* 47:947.
- Koyama, S., Suzuki, K. and Yamazaki, H. 1964. Heat denaturation of lactalbumin. II. Effects of Ca on the heat coagulation of lactalbumin. *Dairy Sci. Abstr.* 26:272.
- Kuipers, A. 1975. Method of preparing a whey protein concentrate from whey. U.S. Patent 3,930,039.
- Larson, B.L. and Roller, G.D. 1955. Heat denaturation of the specific serum proteins in milk. *J. Dairy Sci.* 38:351.
- Lawrence, L.L. and Harper, W.J. 1979. Effects on membrane processing of pretreatments of whey. *J. Agric. Food Chem.* 27:662.
- Lyster, R.L.J. 1972. Reviews of the progress of dairy science. Section C. Chemistry of milk proteins. *J. Dairy Res.* 39:279.
- Mann, F.M. 1977. Preparation and properties of insoluble lactalbumin. Proc. Jubilee Conf. Dairy Sci. Technol., Palmerston North, New Zealand.
- Marschall, S.C. 1978. Advances in whey processing – demineralization and other fractionation processes. *N.Z.J. Dairy Sci. Technol.* 14:103.
- Mathur, B.N. and Shahani, K.M. 1977. Utilization of whey for the manufacture of ricotta cheese. *J. Dairy Sci.* 60 (Suppl. 1): 39.
- Maubois, J.L. 1980. Ultrafiltration of whey. *J. Soc. Dairy Technol.* 33:55.
- McDonough, F.E. and Mattingly, W.A. 1970. Pilot-plant concentration of cheese whey by reverse osmosis. *Food Technol.* 24:88.
- McKenzie, H.A. 1971. β -Lactoglobulins. In: *Milk Proteins*. Volume 2. H.A. McKenzie (Ed.). p. 316. Academic Press Inc., New York, NY.
- Modler, H.W. and Emmons, D.B. 1977. Properties of whey protein concentrate prepared by heating under acidic conditions. *J. Dairy Sci.* 60:177.
- Morr, C.V. and Josephson, R.V. 1968. Effect of calcium, N-ethylmaleimide and casein upon heat-induced whey protein aggregation. *J. Dairy Sci.* 51:1349.
- Morr, C.V. and Lin, S.H. 1970. Preparation and properties of an alcohol-precipitated whey protein concentrate. *J. Dairy Sci.* 53:1162.
- Morr, C.V., Swenson, P.E. and Richter, R.L. 1973. Functional characteristics of whey protein concentrates. *J. Food Sci.* 38:324.
- Morr, C.V. 1978. Functionality of whey protein products. *N.Z.J. Dairy Sci. Technol.* 14:185.
- Morris, C.E. 1981. Recovers whey proteins of 90% purity. *Food Eng. April*. Page 92.
- Muller, L.L. 1978. Observations on the economics of whey utilization. *N.Z.J. Dairy Sci. Technol.* 14:121.
- Nielson, M.A., Coulter, S.T., Morr, C.V. and Roseneau, J.R. 1973. Four factor response surface experimental design for evaluating the role of processing variables upon protein denaturation in heated whey systems. *J. Dairy Sci.* 56:76.
- O'Sullivan, A.C. 1971. Whey processing by reverse osmosis, ultrafiltration and gel filtration-2. *Dairy Ind.* 36:691.
- Panzer, C.C., Schoppet, E.F., Sinnamon, H.I. and Aceto, N.C. 1976. Continuous coagulation of cottage cheese whey proteins. *J. Food Sci.* 41:1293.
- Peri, C. and Dunkley, W.L. 1971a. Reverse osmosis of cottage cheese whey: I. Influence of composition of feed. *J. Food Sci.* 36:25.
- Peri, C. and Dunkley, W.L. 1971b. Reverse osmosis of cottage cheese whey: II. Influence of flow conditions. *J. Food Sci.* 36:395.
- Ramsdell, G.A. and Whittier, E.O. 1953. The effect of heat on the albumin and globulin in milk. *J. Dairy Sci.* 36:437.
- Richert, S.H., Morr, C.V. and Corney, C.M. 1974. Effect of heat and other factors upon foaming properties of whey protein concentrates. *J. Food Sci.* 39:42.
- Richert, S.H. 1975. Current milk protein manufacturing processes. *J. Dairy Sci.* 58:985.
- Robinson, B.P., Short, J.L. and Marshall, K.R. 1976. Traditional lactalbumin-manufacture, properties and uses. *N.Z.J. Dairy Sci. Technol.* 11:114.
- Robinson, R.K. and Tamine, A.Y. 1978. Some aspects of the utilization of whey. *Dairy Ind. Int. March*. Page 14.
- Rose, D. 1962. Factors affecting the heat stability of milk. *J. Dairy Sci.* 45:1305.
- Roualeyn, I., Fenton-May, R.I., Hill, C.G., Jr. and Amundson, C.H. 1971. Use of ultrafiltration/reverse osmosis systems for the concentration and fractionation of whey. *J. Food Sci.* 36:14.
- Rowland, S.J. 1933. The heat denaturation of albumin and globulin in milk. *J. Dairy Res.* 5:46.
- Sarma, S.C. and Batty, J.C. 1979. Recovery of cheese whey proteins through ultrafiltration. *J. Food Sci. Technol.* 16:52.
- Sawyer, W.H., Coulter, S.T. and Jenness, R. 1963. Role of sulfhydryl groups in the interaction of κ -casein and β -lactoglobulin. *J. Dairy Sci.* 46:564.
- Sawyer, W.H. 1968. Heat denaturation of bovine β -lactoglobulin and relevance of disulfide aggregation. *J. Dairy Sci.* 51:323.
- Sawyer, W.H. 1969. Complex between β -lactoglobulin and κ -casein. A review. *J. Dairy Sci.* 52:1347.
- Schmidt, R.H. and Illingworth, B.L. 1978. Gelation properties of whey protein and blended protein systems. *Food Prod. Dev.* 12:60.
- Shahani, K.M. 1979. Newer techniques for making and utilization of ricotta cheese. Proc. 1st Biennial Marshall International Cheese Conference. Page 77.
- Shulkamy, M.T. and Monib, A.F. 1976. Effect of hydrogen ion concentration and heat treatment on the yield of precipitated whey products. *Agric. Res. Rev.* 54:79.
- Smith, B.R. and MacBean, R.D. 1978. Fouling in reverse osmosis of whey. *Aust. J. Dairy Technol.* 33:57.
- Sourirajan, S. 1977. Reverse Osmosis and Synthetic Membranes. National Research Council of Canada Publication, Ottawa, ON. Page 3.
- Southward, C.R. and Goldman, A. 1975. Co-precipitates. A review. *N.Z.J. Dairy Sci. Technol.* 10:101.
- Stadelman, W.J. and Cotterill, O.J. 1973. *Egg Science and Technology*. AVI Publishing Company, Inc., Westport, CT. Page 158.
- Sternberg, M. and Hershberger, D. 1974. Separation of proteins with polyacrylic acids. *Biochim. Biophys. Acta* 342:195.
- Sternberg, M., Chiang, T.P. and Ebert, N.J. 1976. Cheese whey proteins isolated with polyacrylic acid. *J. Dairy Sci.* 59:1042.
- Stirland, J.V. 1978. Processing and marketing of whey: (a) Whey processing. *J. Soc. Dairy Technol.* 31:91.
- Streiff, P.J., Nilson, K.M., Duthie, A.H. and Atherton, H.V. 1979. Whey ricotta cheese manufactured from fluid and condensed whey. *J. Food Prot.* 42:552.
- Thompson, L.U. 1977. Co-precipitation of rapeseed and cheese whey proteins using acid and heat treatment. *Can. Inst. Food Sci. Technol. J.* 10:43.
- Torres, N. and Chandan, R.C. 1981. Latin American white cheese. A review. *J. Dairy Sci.* 64:552.
- Trautman, J.C. and Swanson, A.M. 1958. Additional evidence of a stable complex between β -lactoglobulin and α -casein. *J. Dairy Sci.* 41:715.
- Wa, A.C.M., Bourgh, W.A., Holmes, M.R. and Perkins, B.E. 1978. Influence of manufacturing variables on the characteristics and effectiveness of chitosan products. III. Coagulation of cheese whey solids. *Biotechnol. Bioeng.* 20:1931.
- Workshop Discussion. 1978. Ultrafiltration and reverse osmosis. *N.Z.J. Dairy Sci. Technol.* 14:96.
- Young, R.H. 1980. Upgrading of abattoir waste protein. In: *Developments in Meat Science*. I. R. Lawrie (Ed.). p. 145. Applied Science Publishers Ltd., London, England.
- Zang, J.A. 1966. Sweetening citrus juices. Proceedings of Symposium on Membrane Processes for Industry. Southern Research Institute, Birmingham, AL.
- Zittle, C.A. and Dellamonica, E.S. 1956. Viscosity and flocculation of heated β -lactoglobulin solutions. Effect of calcium concentration and pH. *J. Dairy Sci.* 39:514.
- Zittle, C.A., Thompson, M.P., Custer, J.H. and Cerbulis, J. 1962. κ -casein- β -lactoglobulin in solution when heated. *J. Dairy Sci.* 45:807.

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Cardiac Activity During the Exsanguination of Pigs in an Abattoir

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Abstract

Forty-six pigs were electrically stunned, shackled by a hindlimb, hoisted off the floor and exsanguinated by puncture of the major blood vessels at the base of the neck. Electrocardiograms were recorded from needles in the left and right axillary region. At the time that exsanguination was started, there was no electrocardiographic activity and it was concluded that heart contraction was arrested. The cause of arrest was unknown. The heart might have stopped as a result of electrical stunning, or as a result of increased blood pressure in the head after shackling. After exsanguination was started, the atria and then the ventricles began to contract again, weakly at first but then progressively stronger. Heartbeats occurred for 11.0 ± 4.1 min from the start of exsanguination. Rate of beating was variable after the heart restarted but eventually slowed down. Integrated cardiac activity was sometimes terminated by atrioventricular block or by ventricular fibrillation.

Résumé

Quarante-six porcs furent assommés par choc électrique, entravés par un membre arrière, hissés au-dessus du plancher et saignés par ponction des vaisseaux sanguins principaux à la base du cou. À l'aide d'aiguilles installées dans la région axillaire de gauche et de droite, on a enregistré des électrocardiogrammes. Au début de la saignée, l'activité électrocardiographique était nulle, indiquant ainsi l'arrêt de la contraction du cœur. On ne connaît pas la cause de cet arrêt. Il se peut que le cœur ait arrêté à la suite du choc électrique, ou à cause d'une montée de la pression sanguine au niveau de la tête, suite à la mise en entraves. Après le début de la saignée, on a observé la reprise de la contraction des oreillettes et des ventricules, faiblement au départ et ensuite progressivement plus intense. Les battements du cœur ont duré pendant $11,0 \pm 4,1$ min après le commencement de la saignée. La vitesse des battements était variable au départ mais s'est éventuellement ralentie. Parfois l'activité cardiaque intégrée s'est terminée par obstruction entre oreillette et ventricule ou par fibrillation ventriculaire.

Introduction

The events which occur during the slaughter of meat animals are midway between animal science and food science. Much is known about the cardiovascular physiology of living pigs (Booth *et al.*, 1966; Engelhardt, 1966) but little is known about cardiovascular activity during and after terminal exsanguination under abattoir conditions. The irreversible nature of abattoir exsanguination excludes the topic from the mainstream of veterinary

physiology, since physiology is normally defined as the study of living organisms. Likewise, because the topic has physiological connotations, it is seldom considered to be part of food science. In the latter case, this may be a rather shortsighted omission. In most cases, abattoirs and meat processing plants are closely integrated, both in location and operation. Furthermore, events which occur during animal slaughter probably have some effect on meat quality, since genetically similar animals which have been reared and transported together seldom produce carcasses with identical lean meat quality.

Efficient exsanguination is essential for the humane slaughter of meat animals and for the timing of subsequent operations in the abattoir. The exsanguination of skeletal muscles is the most important step in the biochemical conversion of muscles to meat since it marks the termination of aerobic metabolism. In the period of anaerobic metabolism which follows, the rate and extent of lactate production have a strong effect on a number of pH-dependent aspects of meat quality. Incompletely exsanguinated meat is either condemned or relegated to a low economic category (Warriss, 1977). The collection of blood for the utilization of its protein content is also dependent on the technology of exsanguination. This report describes the behaviour of the heart during a common slaughter procedure for pigs, and it concludes with a discussion of interrelated events which may occur in the remainder of the vascular system.

Materials and Methods

Animals were slaughtered according to the regulations of the Humane Slaughter of Food Animals Act, 1959. Forty-six pigs were electrically stunned (300 V dial setting, 60 Hz, approximate 10 s duration, occipital electrode position) and exsanguinated by puncture of major blood vessels at the base of the neck. Animals ranged in live weight from 20-168 kg and included gilts, barrows and boars, mostly of the Yorkshire breed. Heat and transport stress were minimal.

After animals were tipped from the stunning trap and shackled by one hindlimb, 22-gauge needle electrodes were inserted through the skin approximately 10 cm apart to record electromyographic (EMG) activity from the biceps femoris of the shackled limb. Two other electrodes were placed in the left and right axillary regions to record electrocardiographic (ECG) activity. Animals were then hoisted off the floor and exsanguinated. The rate and extent of exsanguination were evaluated subjectively by the slaughterman and an observer. Pigs with a rapid flow of blood were given a rating of 1, while those with a sluggish flow of mainly venous blood, or with evidence of clotting, were given a rating of 3. A rating of 2 was given to intermediate animals.

Electrical activity was amplified and recorded using a Physiograph (Type PMP-4A, type 7171 hi-gain couplers and type 7070 channel amplifiers; Narco Biosystems, Houston, Tex.). The major problems in working under abattoir conditions were: to prevent the needles from being pulled out by violent reflex activity; to keep carcasses and electronic instruments dry; and to prevent carcasses from swinging. Recognition of artifacts, due to these problems, was facilitated by comparison of EMG and ECG channels. Recordings were made with a coupler gain of $\times 10$, a time constant of 0.03 s, and a filter to block signals above 30 Hz. The incidence of events is reported as the numerator of a fraction while the denominator indicates the number of animals examined, excluding those with spoiled recordings for the event.

Results

EMG activity was found in all carcasses, although in some cases (7/46) peaks of activity did not exceed 8 mv. The number of peaks exceeding 8 mv was counted where possible and, including carcasses with no peaks and excluding those whose peaks were too numerous to count, the mean was 43.8 ± 46.1 . Most peaks corresponded to bursts of activity in both hindlimbs. Only a few carcasses (6/46) showed evidence of EMG activity 7 min after exsanguination.

Duration of ECG activity was recorded as the interval prior to the first minute in which ECG activity did not occur. This was done because carcasses sometimes had odd heartbeats a long time after cessation of rhythmic activity. In most cases, features of the electromyogram were easily recognized: atrial contraction (P), ventricular contraction (QRS) and ventricular repolarization (T), as shown in Figure 1. The mean duration of ECG activity was

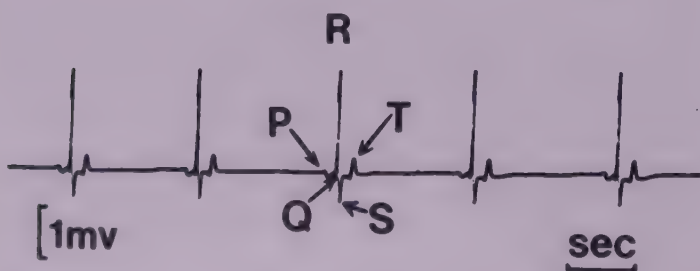


Fig. 1. Features of the electrocardiogram found during exsanguination: atrial contraction, P; ventricular contraction, QRS; ventricular repolarization, T.

11.0 ± 4.1 min, timed from the start of exsanguination.

Initial recordings, made as animals were hoisted off the floor and exsanguinated, were often obliterated by EMG activity from the forelimbs. In most unspoiled recordings (10/12), ECG activity was initially absent and took a while to get restarted (from 2-85 s). Ventricular contraction was preceded by a P wave of atrial contraction (Figures 2a,b,d). Ventricular contractions sometimes took a while to reach their normal strength relative to atrial contraction and ventricular repolarization (Figure 2c). Heart rate was recorded as soon as it was apparent and the mean was 178 ± 67 beats/min. In some animals (26/43), the rate decreased in a simple manner while in others (11/43) it first increased and then decreased. For the remaining animals (6/43), more complex arrhythmic patterns were observed.

ECG amplitudes were affected by the proximity of the recording electrodes to the heart. Since electrode position was difficult to keep constant under abattoir conditions, ECG amplitudes were adjusted to a common basis, related to their initial amplitude. The following amplitudes were measured: (1) initial amplitude, the maximum amplitude of the first QRS wave recorded, (2) maximum amplitude, the maximum QRS reached at any time after exsanguination, and (3) final amplitude, the maximum amplitude of the last QRS in the final minute of ECG duration. Maximum and final amplitudes were divided by their respective initial amplitudes in order to measure changes in amplitude during exsanguination. In most cases (34/40), both maximum and final amplitudes

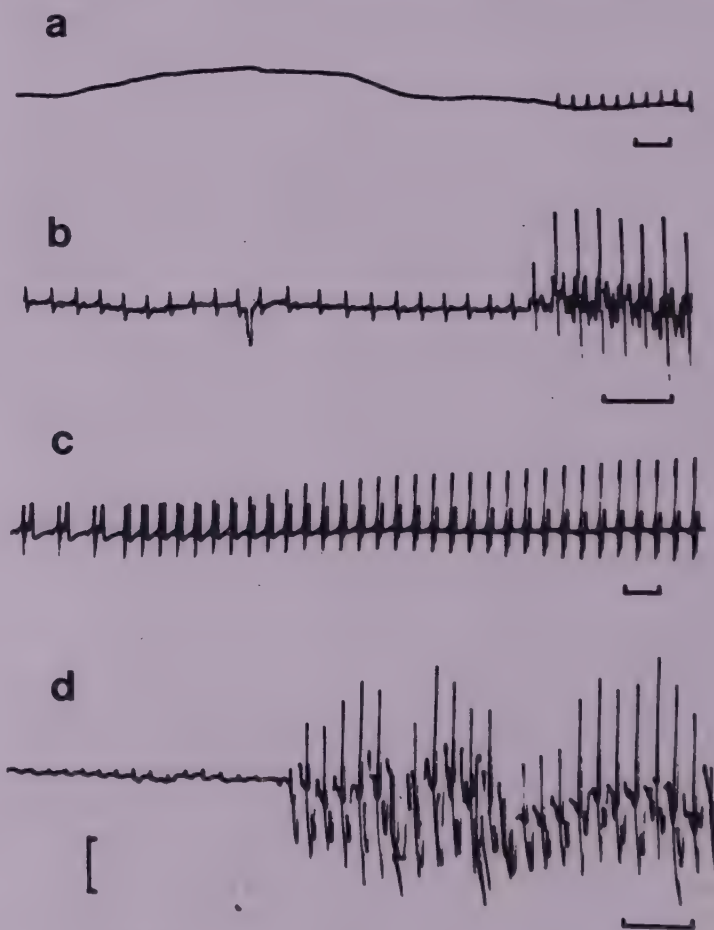


Fig. 2. Restarting of the heart during exsanguination: (a) first P waves, (b) start of atrioventricular conduction, (c) increase in strength of ventricular contraction, (d) atrial contraction initiating complete heartbeat.

increased after exsanguination to 5.86 ± 4.58 and 4.02 ± 3.98 , respectively (40/40). Final amplitude tended to be smaller in carcasses with a long ECG duration ($r = -0.28$, $P < 0.05$).

A number of irregularities in the heartbeat were observed prior to cessation of cardiac activity. These included atrioventricular block and irregular ventricular contraction (Figure 3a), atrial fibrillation with sporadic ventricular response or, possibly, escape (Figure 3b), and ventricular escape after repolarization (Figure 3c).

Termination of heartbeat was sometimes associated with atrioventricular block (7/43), leaving a succession of P waves (Figure 4a). In some cases (11/43), integrated cardiac activity terminated with ventricular fibrillation (Figure 4b,c). Maximum amplitude tended to be smaller ($P < 0.01$) in carcasses with terminal fibrillation than in those without (2.58 vs. 6.92). A similar situation was found for the final amplitude, 2.02 vs. 4.66 ($P < 0.05$).

Antemortem variables such as live weight and sex, and factors such as appearance of exsanguination, were not found to have any relationship to the parameters described above.

Discussion

Vigorous heart pumping is usually thought to be essential for complete exsanguination. Thornton and Gracey (1974), for example, consider that the excellent bleeding of electrically stunned pigs is partly due to continued functioning of the heart. Thus, when exsanguination is incomplete and the meat has an unattractive appearance, premature termination of cardiac activity is blamed. When

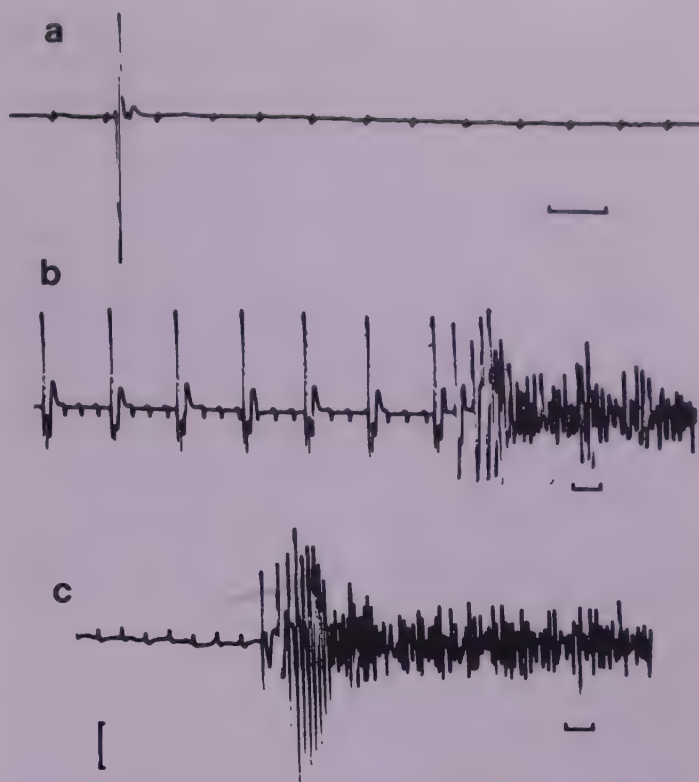


Fig. 4. Termination of coordinated cardiac activity: (a) atrioventricular block, (b and c) ventricular fibrillation.

animals are rendered unconscious for humanitarian reasons before exsanguination, operators attempt to avoid stopping the heart and sometimes err in the direction of inadequate stunning. The results of the present survey call for some re-examination of these conventional beliefs. They may not necessarily be wrong, but they probably oversimplify the complex cardiovascular responses of animals during stunning and exsanguination.

Experimental work would be necessary to determine why the heart is initially inactive under the slaughter procedures used in this study. If the heart is still beating immediately after termination of the stunning current, a likely explanation for cardiac arrest would be the activity of carotid sinus and cephalic baroreceptors (Booth *et al.*, 1966). These might be activated by increased blood pressure due to the pig being suspended with its head downwards. In the head down position, cardiac activity might be restarted by the decline in blood pressure once exsanguination has had effect. The buildup of metabolites in the myocardium, due to hypoxia, might also be involved.

Different stunning methods modify both the conditions that prevail at the start of exsanguination (Leach and Warrington, 1976) and the neural responses to exsanguination (Kollai *et al.*, 1973). For example, electrically stunned sheep lose more blood than those stunned with a captive bolt (Warriss and Leach, 1978). Reduction of blood flow to the kidneys causes the release of a proteolytic enzyme, renin, which acts on a plasma protein to produce a polypeptide, angiotensin I. This polypeptide is enzymatically converted to angiotensin II, which then causes widespread vasoconstriction. Vasoconstriction is important because it decreases the retention of blood in meat (Warriss, 1978). Angiotensin II vasoconstriction is operative in both conscious and anesthetized animals (Miller *et al.*, 1979). Catecholamines and antidiuretic hormone

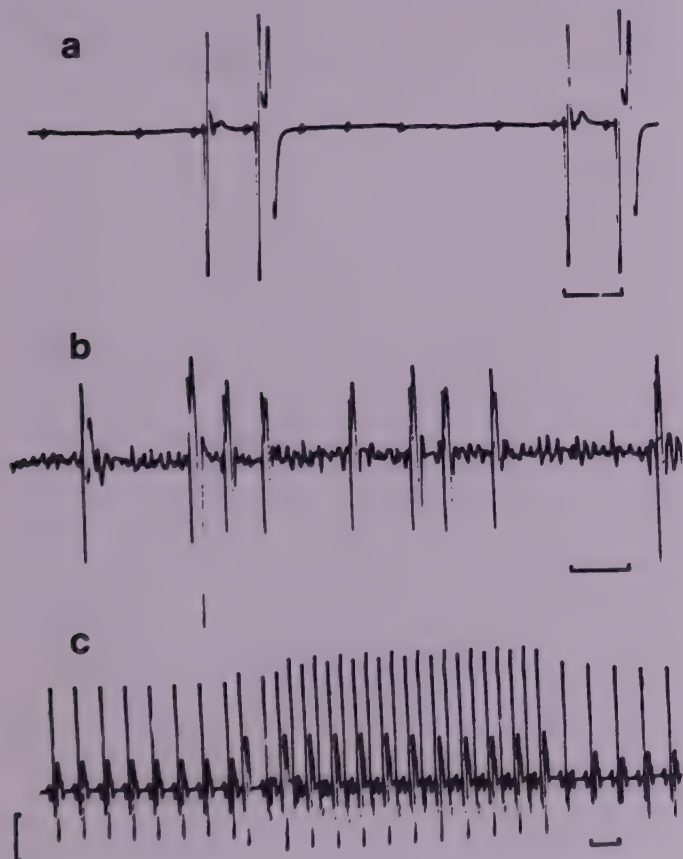


Fig. 3. Irregularities of the electrocardiogram after exsanguination: (a) atrioventricular block and irregular ventricular contraction, (b) atrial fibrillation with sporadic ventricular response, (c) ventricular escape after repolarization.

may also enhance vasoconstriction during exsanguination. Speed of exsanguination may modify the balance between neural and hormonal vasoconstrictive mechanisms, with hormonal vasoconstriction predominating in rapid exsanguination (Hall *et al.*, 1976). However, asphyxia prior to exsanguination may result in vasoconstriction due to the activity of the sympathetic nervous system (Weissman *et al.*, 1978).

Fluid is delivered to muscles by arteries but it may return to the heart by either of two routes, in the venous system or in the lymphatic system. The route taken by intercellular fluid depends primarily on the extent to which fluid is taken up by capillaries and then passed to the venous system. In living animals, venous return is far greater than lymphatic return. The lymphatic capillaries that drain skeletal muscles are mostly found in perimysial connective tissue (Korneliussen, 1975). The small amount of lymph that drains from muscles is increased after neural stimulation and its lactate dehydrogenase content increases dramatically following muscle damage (Bach and Lewis, 1973). In sheep, the flow of lymph from lymph nodes increases within 15 min after stress due to pain (Shannon *et al.*, 1976). Exsanguination may (Lundvall and Hillman, 1978), or may not (Johnson, 1972) cause absorption of intercellular fluid into the bloodstream, depending on the degree of vasoconstriction and consequent hydrostatic pressure in the vasculature. It remains to be determined whether or not proteolytic enzymes, such as renin, or water movements in the body have any effect on meat quality.

Acknowledgement

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References

- Bach, C. and Lewis, G.P. 1973. Lymph flow and lymph protein concentration in the skin and muscle of the rabbit hindlimb. *J. Physiol.* 235:477.
- Booth, N.H., Bredeck, H.E. and Herin, R.A. 1966. Baroreceptor and chemoceptor reflex mechanisms in swine. *In: Swine in Biomedical Research*. L.K. Bustad and R.O. McClellan (Eds.). p. 331. Batelle Memorial Institute, Pacific Northwest Laboratory, Richland, WA.
- Engelhardt, W.v. 1966. Swine cardiovascular physiology. *In: Swine in Biomedical Research*. L.K. Bustad and R.O. McClellan (Eds.). p. 307. Batelle Memorial Institute, Pacific Northwest Laboratory, Richland, WA.
- Hall, J.E., Schwinghamer, J.M. and Lalone, B. 1976. Mechanisms of blood vessel constriction during hemorrhage. *Am. J. Physiol.* 230:569.
- Johnson, G. 1972. Fluid and electrolyte changes in serum and muscle associated with hemorrhagic shock. *J. Surg. Res.* 13:7.
- Kollai, M., Fedina, L. and Kovach, A.G.B. 1973. Effect of bleeding, cooling and asphyxia on the activity of vertebral and cardiac sympathetic nerves. *Acta Physiol. Acad. Sci. Hung.* 44:145.
- Korneliussen, H. 1975. Fenestrated blood capillaries and lymphatic capillaries in rat skeletal muscle. *Cell Tissue Res.* 163:169.
- Leach, T.M. and Warrington, R. 1976. The electrocardiogram of sheep, monitored by radiotelemetry, during electrical or carbon-dioxide stunning and subsequent slaughter. *Med. Biol. Eng.* 14:79.
- Lundvall, J. and Hillman, J. 1978. Fluid transfer from skeletal muscle to blood during hemorrhage. *Acta Physiol. Scand.* 102:450.
- Miller, E.D., Longnecker, D.E. and Peach, M.J. 1979. Renin response to hemorrhage in awake and anesthetized rats. *Circ. Shock* 6:271.
- Shannon, A.D., Quin, J.W. and Jones, M.A.S. 1976. Response of the regional lymphatic system of the sheep to acute stress and adrenaline. *Q. J. Exp. Physiol.* 61:169.
- Thornton, H. and Gracey, J.F. 1974. *Textbook of Meat Hygiene*. Bailliere Tindall, London, England.
- Warriss, P.D. 1977. The residual blood content of meat – a review. *J. Sci. Food Agric.* 28:457.
- Warriss, P.D. 1978. Factors affecting the residual blood content of meat. *Meat Sci.* 2:155.
- Warriss, P.D. and Leach, T.M. 1978. The influence of slaughter method on the residual blood content of meat. *J. Sci. Food Agric.* 29:608.
- Weissman, M.L., Sonnenschein, R.R. and Rubinstein, E.H. 1978. Mechanisms of vascular changes in skeletal muscle during asphyxia in the cat. *Am. J. Physiol.* 235:H72.

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Determination of α - and β -Carotene in Fruit and Vegetables by High Performance Liquid Chromatography

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Abstract

A simple, reproducible isocratic high performance liquid chromatographic procedure has been developed to separate α - and β -carotene in lowbush blueberries, carrots, potatoes and fiddlehead greens. Analyses were performed using a Partisil 5 ODS column maintained at ambient temperature with a mobile phase of 85:12.5:2.5 acetonitrile-tetrahydrofuran-water. Detection was at 470 nm and 0.04 absorbance units full scale. Total analysis time, including extraction, was 30-40 min. Saponification was not required for cleanup or recovery even with samples containing large amounts of other pigments, such as blueberries and fiddlehead greens. The quantity of α -carotene varied from 1 $\mu\text{g}/100$ g wet weight of blueberries and potatoes to 8,800 $\mu\text{g}/100$ g wet weight of carrots, while β -carotene ranged from 6 $\mu\text{g}/100$ g wet weight of potatoes to 28,100 $\mu\text{g}/100$ g wet weight of carrots. A comparison made between this method and the AOAC procedure did not demonstrate close agreement between values obtained by the two methods.

Résumé

Pour séparer les carotènes alpha et beta chez des bleuets nains, les carottes, les pommes de terre et les fougères tête de violon, on a développé une procédure par chromatographie en phase liquide isocratique à haute résolution qui est simple et reproductible. Les analyses furent réalisées à l'aide d'une colonne de Partisil 5 ODS maintenue à la température ambiante avec une phase mobile d'acétonitrile-tétrahydrofur-eau dans le rapport 85:12,5:2,5. La détection fut faite à 470 nm pour une échelle complète de 0,04 unités d'absorbance. Le temps total requis pour l'analyse, y compris l'extraction, fut 30-40 min. Il ne fut pas nécessaire d'avoir recours à la saponification pour le nettoyage ou la récupération même dans le cas d'échantillons riches en d'autres pigments comme les bleuets et les fougères tête de violon. La quantité d' α -carotène a varié de 1 $\mu\text{g}/100$ g, base humide, chez les bleuets et les pommes de terre à 8,800 $\mu\text{g}/100$ g, base humide, chez les carottes tandis que le β -carotène a varié de 6 $\mu\text{g}/100$ g, base humide, chez les pommes de terre à 28,100 $\mu\text{g}/100$ g, base humide, chez les carottes. La concordance entre cette méthode et celle de l'AOAC a été faible.

Introduction

The vitamin A activity of fruits and vegetables is due to the presence of carotenoids (provitamin A compounds). Of the numerous carotenoids known, only ten have provitamin A activity, and each of the ten possesses a

varying degree of activity (Sweeney and Marsh, 1970; Bauernfeind, 1972). These provitamin A compounds are comprised of α - and β -carotene and their stereoisomers along with γ -carotene and cryptoxanthin (Sweeney and Marsh, 1970). In most vegetables and many fruits (the major exception being citrus fruit), the majority (85-97%) of all provitamin A activity is due to the *trans* forms of α - and β -carotene (Sweeney and Marsh, 1971). During processing, the *trans* isomers can be converted to the *cis* forms, which have less vitamin A activity than the *trans* forms (Sweeney and Marsh, 1971).

Because of the number of carotenoids that possess vitamin A activity and because of the variation in the degree of their vitamin A activity, there is a need to have a simple and rapid method that would yield a reasonable value for vitamin A activity in fresh and processed fruits and vegetables. Such a method would be helpful in nutritional labelling, and for nutritionists, plant biochemists and horticulturists. The methodologies available for determining carotenoids can be grouped into three chromatographic categories – open column, thin layer chromatography (TLC) and high performance liquid chromatography (HPLC). The open column techniques (Purcell, 1958; Rodriguez *et al.*, 1976; Gebhardt *et al.*, 1977; AOAC, 1980), of which the AOAC is the most widely used, are very time consuming, not as quantitative as other methods due to the numerous steps, and for the most part cannot distinguish between α - and β -carotene. Furthermore, open column procedures that can distinguish between isomers are extremely tedious (Rodriguez *et al.*, 1976; Gebhardt *et al.*, 1977). The thin layer procedures are lengthy and the separation and quantitation of the carotene isomers is difficult (Randerath, 1963; Bolliger, 1965; Davies, 1965; Strain and Svec, 1969; Baloch *et al.*, 1977). High performance liquid chromatography techniques are generally considered to be the quickest, simplest and most reproducible methods of analyzing carotenoids in fruits and vegetables (Sweeney and Marsh, 1970; Van

DeWeerdhof *et al.*, 1973; Stewart, 1977a,b; Giuseppe *et al.*, 1978; Zakaria *et al.*, 1979). The most extensive system has been developed by Sweeney and Marsh (1970), with which all the active forms of the carotenoids can be separated. This procedure is very lengthy, however, since an open column separation is initially used followed by two HPLC separations on columns that are not commercially available. In addition to this procedure, other methods have been developed for citrus fruits (Stewart, 1977a,b; Giuseppe *et al.*, 1978). Recently Zakaria *et al.* (1979) developed an HPLC separation for carotenoids in tomatoes. This procedure was one of the first methods to use a commercially available (ODS) HPLC column for carotenoid analysis.

This paper describes a rapid HPLC method, which uses an ODS column, for the analysis of α - and β -carotene in blueberries, potatoes, carrots and fiddlehead greens. A simple method requiring no saponification or open column chromatography and in many instances no partitioning step is used.

Materials and Methods

Materials

Trans α - and β -carotene standards were obtained from Sigma Chemical Co., St. Louis, Mo. Magnesium carbonate anhydrous powder and sodium sulphate anhydrous granular form were purchased from Fisher Scientific Co., Fair Lawn, N.J. The C_{18} and silica gel G thin layer chromatography plates were purchased from Whatman, Inc., Clifton, N.J. and Applied Science, State College, Penn., respectively. All solvents were purchased from Fisher Scientific Co.

Acetone, petroleum ether, methylene chloride, hexane and tetrahydrofuran stabilized with BHT and methanol were ACS grade, while the acetonitrile and water were HPLC grade. The vegetables and fruit were purchased from local stores (except for the fiddlehead greens, which were picked at various locations in the state).

Standard Solutions

Stock solutions of *trans* α - and β -carotene were prepared by weighing 10 mg of α -carotene and 25 mg of β -carotene into separate 100 mL actinic volumetric flasks. The flasks were brought to volume with a 60:40 solution of hexane-acetone. Aliquots of 1, 2 and 3 mL were removed from each stock solution and placed into three 50 mL actinic volumetric flasks. These aliquots were evaporated to dryness using prepurified nitrogen (Union Carbide, W. Va.), after which the residues were dissolved and brought to volume with tetrahydrofuran. Five μ L of each standard were injected. Because peak height was directly proportional to concentration over the working range of concentrations, quantitation was performed using peak height.

Liquid Chromatography

A Waters Model ALC/GPC 244 liquid chromatograph equipped with a Schoeffel UV-visible detector set at 470 nm and 0.04 absorbance units full scale was employed. A Partisil 5 ODS column 25 cm x 4.6 mm ID (Whatman, Inc., Clifton, N.J.) along with a solvent system of acetonitrile-tetrahydrofuran-water (85:12.5:2.5) pumped at a flow rate of 2.0 mL/min were used.

Analysis of α - and β -Carotene in Fruit and Vegetables by HPLC

A 10 g sample of carrots or fiddleheads was extracted with 20 g anhydrous Na_2SO_4 , 1.0 g $MgCO_3$ and 100 mL of tetrahydrofuran in a Waring blender (quart jar size) at a moderate speed for 5 min. The extract was vacuum filtered through a Buchner funnel fitted with Whatman #54 filter paper. Most samples had to be extracted twice to remove all the carotenes. The carrot filtrate was concentrated to 75 mL using a rotary evaporator set at 40°C, transferred to a 100 mL actinic volumetric flask and brought to volume with tetrahydrofuran, while the fiddlehead sample was concentrated to 10 mL and brought to a 25 mL volume. A 5 μ L sample was injected.

For the other vegetable and fruit (potatoes and blueberries) in which the quantities of α - and β -carotene are much less, the 10 g sample was extracted, filtered and partitioned into petroleum ether. The tetrahydrofuran extract was placed in a 1,000 mL separatory funnel followed by 200 mL of petroleum ether and 250 mL of distilled water. This mixture was shaken for 2 min with the bottom layer being extracted once more with 100 mL of petroleum ether. (Two extractions were sufficient to remove all carotenes.) The petroleum ether fractions were combined, dried over Na_2SO_4 and evaporated to dryness using a rotary evaporator set at 40°C. The residue was transferred to a 25 mL actinic volumetric flask using tetrahydrofuran. An aliquot of 10 mL was removed, evaporated to dryness with nitrogen and redissolved in 0.3 mL of tetrahydrofuran. A 20 μ L sample was injected.

Recovery Study

Percent recovery studies were performed by adding 0.25 and 0.75 mg of β -carotene to 10 g of raw carrots. Three replications were made at each spiking level. For the determination of the β -carotene values of the carrots before spiking, three subsamples were removed and extracted.

Repeatability Study

Eight products (100 g each) were blended without solvent in a Waring blender to obtain a uniform sample. Four 10 g subsamples were removed and extracted and quantified using the procedure described above. Coefficients of variation were used to determine the reproducibility of this method for determining α - and β -carotene for each product.

Open Column Analysis of α - and β -Carotene

The AOAC (1980) method for the determination of carotene in fresh plant materials was followed.

Identification of the HPLC Peaks

Tentative identification of α - and β -carotene was made using retention time comparison with actual standards. Two thin layer chromatography systems were also used. One was silica gel G with an eluant of methanol-petroleum ether (0.5:99.5) and the other a reverse phase system with a solvent mixture of acetonitrile-tetrahydrofuran-water (85:12.5:2.5). Finally, visible spectra from 400-500 nm were taken on a Beckman DU 8 spectrophotometer, Fullerton, Calif. The samples were dissolved in hexane.

Results and Discussion

Chromatograms depicting the separation of α - and β -carotene in carrots, potatoes, fiddlehead greens and lowbush blueberries are shown in Figure 1. The peaks corresponding to α - and β -carotene are designated by the

numbers 1 and 2, respectively. Although 100% resolution is not achieved (actually resolution is approximately 90%), α - and β -carotene are still easily and accurately quantified. The repeatability from injection to injection was good. A carrot sample was injected twenty-six times consecutively and the coefficients of variation of the

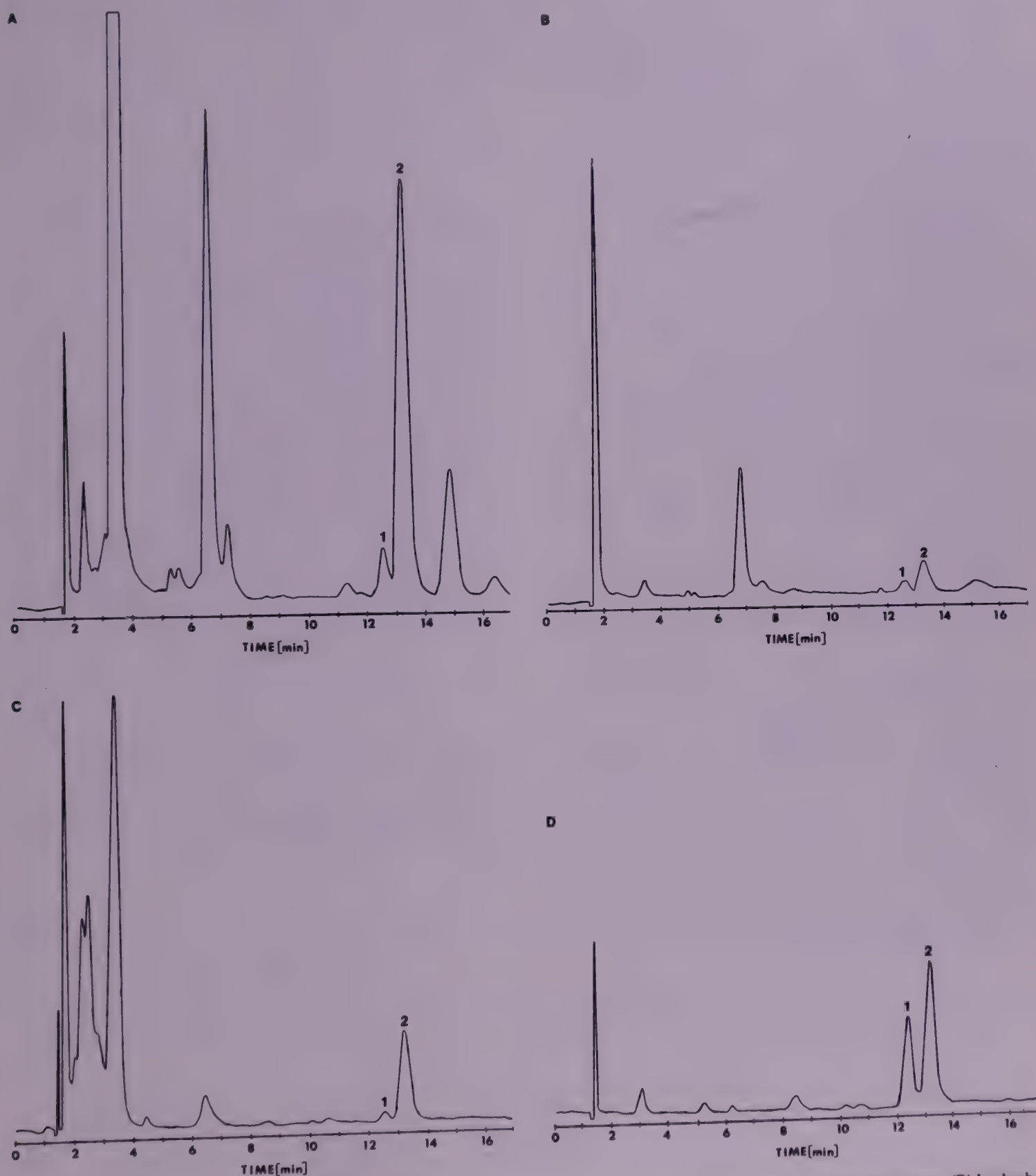


Fig. 1. High performance liquid chromatograms of extracts of four commodities containing α - and β -carotene. (A) Fiddlehead greens, (B) lowbush blueberries, (C) potatoes, and (D) carrots. Peaks #1 and #2 refer to α - and β -carotene, respectively. Conditions: column, Partisil 5 ODS; mobile phase, acetonitrile-tetrahydrofuran-water (85:12.5:2.5%); flow rate 2 mL/min; column temperature, ambient; wavelength, 470 nm; absorbance units full scale, 0.04; injection volume, 10 μ L for A, 20 μ L for B, C and 5 μ L for D.

peak heights for α - and β -carotene were 2.39% and 3.19%, respectively. As seen in the chromatograms there are other substances, besides α - and β -carotene, which are eluted by this system. Separation takes approximately 14-17 min, dependent upon the presence of other pigments which are eluted after β -carotene. The entire procedure, including sample preparation, takes 30-40 min and thus is a faster procedure than those described in previous methods.

The extraction procedure described for products containing small amounts of carotenes (blueberries and potatoes) requires more time to complete than the one used for carrots and fiddlehead greens. However, by setting the absorbance units on the detector to 0.02 absorbance units full scale and using the extraction method described for the fiddleheads, α - and β -carotene can be analyzed in such commodities as potatoes and blueberries employing the simple extraction procedure.

Although the HPLC analysis was only performed on four different plant products, the products were selected to include varied types. The products differ in quantity and type of pigment, such as chlorophylls and anthocyanins, as well as the carotenoids. Thus these four plant materials should be a good representation of all fruits and vegetables, with the exception of citrus fruits.

Analyses were performed both with and without saponification. No differences were observed between treatments in the quantity of α - and β -carotene. This may indicate that there were no interfering compounds present in these four food products which were removed by saponification, and that α - and β -carotene were not bound to lipids in the plant matrix.

In the recovery study carried out using β -carotene and carrots, complete extraction of pigments was easily determined by colour removal. This was confirmed by adding

β -carotene at two different levels, 0.25 and 0.75 mg/10 g of carrots, and extracting.

Both spiking levels yielded a mean percent recovery of 100.5 which demonstrated that the tetrahydrofuran procedure effectively extracts β -carotene. Although β -carotene was the only carotene used in the recovery experiment, α -carotene should behave similarly.

For determining the repeatability of this method, eight products were analyzed four times each for their α - and β -carotene content. The results are given in Table 1. Coefficients of variation range from 1.10 to 14.16%, with all but one being below 10%. The largest coefficient of variation was for α -carotene in potatoes, which contained the least amount of α -carotene of all the products analyzed. The method then is very repeatable.

Various commercial products were analyzed for their α - and β -carotene content. As indicated in Table 2, several different brand names of the same food were analyzed. As would be expected, carrots had the largest quantity of α - and β -carotene and thus the highest vitamin A value. The lowest carotene content was observed in blueberries and potatoes. Fiddlehead greens compared well (40% of the RDA for vitamin A) in the amount of provitamin A with common greens like swiss chard, spinach and collards (Sweeney and Marsh, 1971). Variability in provitamin A activity was high within the different brands of the same product and between different products. The greatest deviations were observed in carrots.

Finally, a comparison between the HPLC and AOAC methods was made. As shown in Table 3, the vitamin A value observed for each of the foods was higher when the AOAC method was used. These differences occur because in the open column technique, carotenoids which do not have provitamin A activity, such as lycopene and the monohydroxy carotenoids, also elute from the column

Table 1. Repeatability of α - and β -carotene determination.

Product	Number of subsamples	$\mu\text{g}/100\text{ g}$		CV ¹ α -carotene	CV β -carotene
		α -carotene	β -carotene		
Raw carrots	4	3,500	9,100	1.10	1.26
Cooked diced carrots	4	4,400	10,600	6.14	3.96
Raw carrots	4	3,700	5,600	7.02	7.68
Cooked sliced carrots	4	3,400	8,800	5.29	3.98
Frozen carrots	4	8,600	26,900	1.98	3.75
Raw fiddlehead greens	4	331	2,050	4.81	5.69
Frozen blueberries	4	2	14	6.40	8.60
Raw potatoes	4	1	6	14.16	6.35

¹Coefficient of variation (%).

Table 2. α - and β -carotene content of various commercial products.

Product	Number of brands analyzed ¹	μg carotene/100 g product		IU vitamin A/100 g ²
		α -carotene	β -carotene	
Raw carrots	8	2,000-5,900	4,600-12,500	9,433-26,045
Canned carrots	3	3,200-4,800	7,000-11,000	14,494-22,573
Frozen carrots	1	8,400-8,800	26,000-28,100	50,753-54,606
Fiddlehead greens	3	90-331	1,200-2,050	2,070-2,888
Raw potatoes	3	1-8	6-40	11-74
Frozen blueberries	2	1-4	13-15	23-29

¹Means of four analyses.

²Based on 1.667 international units vitamin A/ μg of β -carotene (β -carotene = 100%, α -carotene = 53%).

Table 3. Comparison¹ of the HPLC and AOAC methods for determining carotenes and vitamin A values.

Product	Carotenes ($\mu\text{g}/100\text{ g}$)		IU vitamin A/100 g ²	
	AOAC (total)	HPLC (α - and β -)	AOAC (total)	HPLC (α - and β -)
Raw carrots #1	14,000	12,600	23,338	18,087
Diced cooked carrots	17,600	15,000	29,298	21,296
Sliced cooked carrots	19,000	11,900	31,715	16,733
Raw carrots #2	11,800	9,300	19,586	12,394
Sliced cooked carrots #2	15,000	12,200	25,047	17,483
Raw carrots #3	12,800	10,400	21,379	15,086
Raw carrots #4	17,900	16,000	29,756	22,729
Raw fiddlehead greens #1	5,300	2,381	8,835	3,969
Raw fiddlehead greens #2	4,200	1,500	7,001	2,501
Raw potatoes	57	8	96	12
Frozen blueberries #1	170	15	283	24

¹All values represent the average of four determinations.

²Based on 1.667 international units vitamin A/ μg of β -carotene (β -carotene = 100%, α -carotene = 53%).

and are quantified. Furthermore, the AOAC method cannot distinguish between α - and β -carotene, and α -carotene has only 53% of the activity that β -carotene has. The result is a higher than actual value for provitamin A activity when using the open column method. The HPLC method will give a slightly lower value for provitamin A than Sweeney and Marsh's (1970) procedure, possibly because α - and β -carotene only comprise 85-97% of the vitamin A value of fruits and vegetables.

Confirmation of products of the two HPLC peaks tentatively identified as α - and β -carotene by comparison of retention times with standards was performed using TLC and visible spectrophotometry (scanning from 400-500 nm). Two TLC systems were employed, silica gel G and reverse phase plates. The R_f values of the collected peaks agreed with α - and β -carotene standards. Visible spectra from 400-500 nm of the two peaks also compared well with α - and β -carotene standards. Peak maxima of 419, 442 and 471 nm were observed for the peak tentatively identified as α -carotene (α -carotene standard 418, 442, 471 nm), while maxima of 448 and 475 nm were observed for peak #2, tentatively identified as β -carotene (β -carotene standard 448 and 475 nm).

This new HPLC method for the determination of α - and β -carotene in fruit and vegetables is rapid and precise, and would be useful in nutritional labelling and for studying the effects of different cultural and processing treatments on the effects of these two carotenoids.

References

- AOAC. 1980. Official Methods of Analysis, 13th ed., p. 738. Association of Official Analytical Chemists, Washington, DC.
- Baloch, A.K., Buckle, K.A. and Edwards, R.A. 1977. Separation of carrot carotenoids on hyflo super-cel-magnesium oxide-calcium sulfate thin layers. *J. Chromatogr.* 139:149.
- Bauernfeind, J.C. 1972. Carotenoid vitamin A precursors and analogs in food and feeds. *J. Agric. Food Chem.* 20:456.
- Bolliger, H.R. 1965. Vitamins. In: *Thin-Layer Chromatography: A Laboratory Handbook*. E. Stahl (Ed.). p. 210. Academic Press Inc., New York, NY.
- Davies, B.H. 1965. Analysis of carotenoid pigments. In: *Chemistry and Biochemistry of Plant Pigments*. T.W. Goodwin (Ed.). p. 489. Academic Press Inc., New York, NY.
- Gebhardt, S.E., Elkins, E.R. and Humphrey, J. 1977. Comparison of two methods for determining the vitamin A value of clingstone peaches. *J. Agric. Food Chem.* 25:629.
- Giuseppe, C., Giuseppe, M. and Paola, C. 1978. Determination of α - and β -carotene in citrus juices by high-pressure liquid chromatography. *Essenzl Deriv. Agrum.* 48:359.
- Purcell, A.E. 1958. Partition separation of carotenoids by silica-methanol columns. *Anal. Chem.* 30:1049.
- Randerath, K. 1963. Carotenoids and chlorophylls. In: *Thin-Layer Chromatography: A Laboratory Handbook*. E. Stahl (Ed.). p. 152. Academic Press Inc., New York, NY.
- Rodriguez, D.B., Raymundo, L.C., Lee, T.C., Simpson, K.L. and Chichester, C.O. 1976. Carotenoid pigment in ripening *Momordica charantia* fruits. *Ann. Bot.* 40:615.
- Stewart, I. 1977a. High-performance liquid chromatographic determination of provitamin A in orange juice. *J. Assoc. Off. Anal. Chem.* 60:132.
- Stewart, I. 1977b. Provitamin A and carotenoid content of citrus juices. *J. Agric. Food Chem.* 25:1132.
- Strain, H.H. and Svec, W.A. 1969. Procedures for the chromatography of fat soluble chloroplast pigments. *Adv. Chromatogr.* 8:119.
- Sweeney, J.P. and Marsh, A.C. 1970. Vitamins and other nutrients. Separation of carotene stereoisomers in vegetables. *J. Assoc. Off. Anal. Chem.* 53:937.
- Sweeney, J.P. and Marsh, A.C. 1971. Effect of processing on provitamin A in vegetables. *J. Am. Diet. Assoc.* 59:238.
- Van DeWeerdhof, T., Wiersum, M.L. and Reissenweber, H. 1973. Application of liquid chromatography in food analysis. *J. Chromatogr.* 83:455.
- Zakaria, M., Simpson, K., Brown, P.R. and Krstulovic, A. 1979. Use of reversed-phase high-performance liquid chromatographic analyses for the determination of provitamin A carotenes in tomatoes. *J. Chromatogr.* 176:109.

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The Effect of Cow Size, Milk Yield and Cow Fatness on the Carcass Characteristics and Meat Quality of Their Progeny

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Abstract

Cattle were produced from a foundation herd having a wide range in mature size and milk yield. All heifers were bred to Angus sires to minimize calving problems. All cows were bred to a Simmental sire for second and third calves. Calves (heifers and steers) were weaned at about 6 mo of age and fed a diet largely based on corn silage. Cattle by Angus sires were slaughtered at 10 mm backfat thickness evaluated ultrasonically and those by Simmental sires at 7 mm. One side of each carcass was separated into fat, lean and bone. The m. longissimus dorsi from the 9-10-11th rib region was removed, vacuum packaged and stored at -29°C for later quality determinations. A 100 kg increase in cow weight alone gave calves that were 28 kg heavier at slaughter, 14 kg more lean tissue, 1.8 kg more fat and 3.4 kg more carcass bone. Dam's milk yield had no significant effect on carcass tissue yield. A 1 mm increase in fatness of dam at calving decreased progeny carcass lean yield by 2.6 kg, fat by 0.4 kg and bone by 0.8 kg. All the cow factors measured (cow size, milk yield, cow fatness) had no significant effect on taste panel scores for flavour, juiciness, tenderness or overall acceptability. There were also no differences between steers and heifers for taste panel scores. It was concluded that cow factors have little overall effect on the final meat quality of their calves when comparisons are made at similar carcass fatness.

Résumé

Des bovins furent obtenus à partir d'un troupeau de base représentant une grande marge d'âge, de taille et de rendement en lait. Toutes les génisses furent croisées à des taureaux Angus pour minimiser les problèmes de mise bas. Toutes les vaches furent croisées à un taureau Simmental pour les deuxième et troisième mises bas. Les veaux (génisses et bouvillons) furent sevrés aux environs de 6 mo et ensuite nourris principalement à l'ensilage de maïs. Les bovins provenant des taureaux Angus furent abattus lorsque l'épaisseur du gras dorsal eût atteint 10 mm au test ultrasonique et ceux des taureaux Simmental, à 7 mm. Un côté de chaque carcasse fut fractionné en gras, maigre et os. Le muscle longissimus dorsi fut prélevé au niveau des côtes 9, 10 et 11. Il fut aussitôt emballé sous vide et entreposé à -29°C pour les examens qualitatifs ultérieur. Une augmentation de 100 kg dans le poids de la vache a correspondu à des veaux plus lourds de 28 kg à l'abattage dont 14 kg de tissu maigre, 1,8 kg de gras et 3,4 kg d'os de carcasse. Aucun rapport significatif n'a été observé entre le rendement en lait de la mère et le rendement en tissu des carcasses. Une augmentation de 1 mm en gras dorsal chez la mère à la mise bas a correspondu à une

diminution au niveau des carcasses de la progéniture de 2,6 kg de tissu maigre, de 0,4 kg de gras et de 0,8 kg d'os. Tous les facteurs étudiés se rapportant à la vache (taille de la vache, rendement en lait, graisse de la vache) ont été sans influence significative sur les notations sensorielles pour le goût, la succulence, la tendreté ou l'acceptabilité générale. Les évaluations sensorielles n'ont pas différencié non plus entre les bouvillons et les génisses. Il a été conclu que les facteurs se rapportant à la vache avaient peu d'effet d'ensemble sur la qualité finale de la viande de leurs veaux quand les comparaisons furent faites sur des carcasses d'égale richesse en gras.

Introduction

Crossbreeding is now a relatively common practice in commercial beef operations in North America. This has been largely stimulated by the importations of European breeds in the late sixties and early seventies. The imported sire breeds have received a great deal of attention from many researchers (Smith *et al.*, 1976; Young *et al.*, 1978) particularly in their ability to improve important factors such as feedlot gain, feed conversion and carcass quality. However, little information has been collected on the role of maternal effects in the cow herd after using bulls of different mature size. Milk yield of the dam has been shown to be an important factor in calf weaning weight, and yet there is considerable variation both within and among breeds (Rutledge *et al.*, 1971; Butson *et al.*, 1980). Dairy breeds such as the Holstein or Brown Swiss might thus have a role in the crossbred cow, but inclusions of dairy breeds may lead to inferior carcass quality, particularly with respect to muscle:bone ratio. Cow size has been the subject of a great deal of research (Morris and Wilton, 1976), but little has been published on its possible effects on the carcass characteristics and meat quality of progeny. Cow fatness or condition has also been shown to be highly related to reproductive performance (Spelbring *et al.*, 1977), but little has been reported on its effects on progeny carcass characteristics.

The main objectives of this study were to determine the effects of cow factors (cow size, milk yield, cow fatness) on the carcass characteristics and meat quality of their progeny.

Materials and Methods

Angus, Hereford and Shorthorn cows were bred by bulls of the same three breeds to produce both straightbred and crossbred calves. These breeds of cows were bred by bulls of the larger beef breeds including Charolais, Chianina, Limousin and Maine-Anjou and dairy breeds including Jersey, Ayrshire, Holstein and Brown Swiss. These matings produced female offspring which had an extremely wide range in potential for both mature size and potential milk yield. All heifer calves were reared on a conventional diet of corn silage with a minimum of grain supplementation and bred to Angus sires to calve at 2 years of age. Angus sires were used to minimize calving difficulty. As many of these heifers as possible were retained to produce second and third calves. All second and third calves were sired by a Simmental bull. Calvings took place over a period of time from 1969 to 1975, either in spring or fall. Calving time and parity were considered in classifying observations by experimental group. Size of cow was measured as the weight of the cow taken within 7 days post calving. Fatness of the cow was measured as the depth of backfat at the 11/12 rib measured ultrasonically with a Scanogram Model 722 or Model 721 (Ithaca, N.Y.). Milk yield was measured by the calf nursing procedure (weigh calf before and after suckling) at approximately 6, 14 and 22 weeks post calving as described by Mandragon-Vasquez (1981).

All calves from both the Angus and Simmental matings were weaned at 6-7 mo of age and placed on a finishing ration. These animals were fed diets that were primarily corn silage and high moisture corn with an average energy density of 11.2 kJ/kg. Feeding was to an end point of 10 mm backfat in the case of Angus sired calves and 7 mm backfat in the case of the Simmental sired calves. A lower level of finish for Simmental sired calves was used to reduce the length of the feeding period. All carcasses fulfilled requirements for Canada grade A. Backfat was measured ultrasonically at the 11/12 ribs to determine when animals were to be slaughtered.

All animals were slaughtered at the University of Guelph abattoir following established procedures. One side of all the carcasses was separated into fat, lean and bone, after hanging for 7 days at a cooler temperature of 3°C. The m. longissimus dorsi (LD) from the 9-10-11th ribs was removed from the dissected residues, vacuum packaged and stored at -29°C for later determinations of quality.

The roasts were later selected from the freezer by a process of stratified randomization. Roasts were put into one of the three groups based on the animal's dam size (small, medium, large) and selected from these groups at random. All roasts were thawed at room temperature for 24 h and then dry roasted at 177°C to an internal temperature of 72°C. For sensory evaluation 1.3 cm cubes were cut from the 9-10th rib of the LD and allowed to equilibrate to room temperature (21°C). The cubes of meat were scored for juiciness (impression after continued

chewing), flavour, tenderness and overall acceptability by an eight member semi-trained panel on an unstructured 15 cm scale. Meat samples for objective measurements were taken after cooking from the 11th rib adjacent to those used for sensory evaluation. These cores, 2.54 cm in diameter, were taken across the face of the LD and sheared on a Warner Bratzler shear. Shear values were recorded as maximum force in kg/2.54 cm core.

The least squares method described by Harvey (1960) for multiple classifications with unequal subclass numbers was used to study the effect of cow factors on the carcass characteristics and meat quality of their progeny. There were 627 observations for all carcass characteristics and 124 for meat quality (taste panel) measurements, with these being a representative sample of the total set of observations. Cow factors (size, milk yield) were considered to be independent continuous variables and were incorporated as regression effects in analyses that also included experimental group, sex of calf, breed of sire and sire within breed. Regression coefficients were thus adjusted for sex of calf, breed of sire, sire within breed, parity and calving time. Separate analyses were initially conducted for the Angus and Simmental sired cattle. Regression coefficients were homogeneous (Neter and Wasserman, 1974) and common slopes were fitted and presented in this paper from pooled data. Means were computed both for breed of sire (Angus or Simmental) and sex of calf, although the former could not be statistically compared due to confounding of sire of calf and age of dam.

Results and Discussion

The effects of cow factors on some of the more important performance variables of their calves are shown in Table 1. A 100 kg increase in cow weight gave calves that were 28 kg heavier at slaughter and 19 kg heavier in cold carcass weight; however, the calves took 14 days longer to reach the slaughter point. Young *et al.* (1978) found that Charolais sired cows produced calves which were 17 kg heavier than Angus or Hereford sired cows at 452 days of age. Although it is a biological fact that larger cows produce larger calves, no other study has shown the regression of calf slaughter weight on cow weight. The regressions are due to dam effects only. Sire effects can also influence weights and would be in addition to dam effects. Quite large increases in calf slaughter weight could thus be predicted by a 100 kg increase in cow weight.

Milk yield of cow had little effect on slaughter age and a 100 kg increase in milk yield only gave a 2.5 kg increase in slaughter weight. Several authors (Notter *et al.*, 1978; Butson *et al.*, 1980) have reported that cow milk yield has an important relationship with calf weaning weight, and selection for increased lactation performance can effect meaningful increases in calf weaning weights. No other study has followed the effect of milk through to the slaughter endpoint, and it appears by this stage that milk yield of the cow has very little effect on weight or age at slaughter.

Cow fatness had an effect on slaughter endpoint variables. A 1 mm increase in fat depth of the dam (Table 1)

Table 1. Partial regressions of carcass characteristics¹ on cow size, milk yield and cow fatness and least square means for breed of sire and sex of calf.

Dependent variable	Independent variable	Partial regression coefficient	±SE	R ²	Breed of sire least square means		Sex of calf least square means	
					Angus	Simmental	Female	Male
Slaughter age (days)	Cow weight (kg)	0.14	0.026	0.48	430.7	474.6	452.9*	460.1
	Milk yield (kg)	-0.009	0.0036					
	Cow fatness (mm)	-4.3	0.54					
Slaughter weight (kg)	Cow weight (kg)	0.28	0.028	0.67	392.9	479.3	422.9*	470.5
	Milk yield (kg)	0.025	0.0039					
	Cow fatness (mm)	-5.7	0.59					
Cold carcass weight (kg)	Cow weight (kg)	0.19	0.019	0.67	229.4	285.1	249.1*	278.5
	Milk yield (kg)	0.013	0.0026					
	Cow fatness (mm)	-3.9	0.39					
Dressing (%)	Cow weight (kg)	0.003	0.0013	0.16	59.7	60.4	59.9	60.3
	Milk yield (kg)	0.0	0.0					
	Cow fatness (mm)	-0.1	0.03					
Marbling ²	Cow weight (kg)	-0.003	0.0006	0.14	6.1	6.2	6.3	6.1
	Milk yield (kg)	0.0	0.0					
	Cow fatness (mm)	0.0	0.0					

¹Regression for subjective estimation of meat colour, carcass texture and carcass firmness was not significant.²Marbling measured on a nine point scale.

*Means for sex were all significantly different (P<0.05).

gave a reduction in 4.3 days in time to slaughter and a decrease in slaughter weight of 5.7 kg. Cows that had put on fat on a constant energy intake appeared to have calves that were early fattening.

Sex of calf had significant (P<0.05) effects on the overall means (Table 1). Males were older and heavier at slaughter than heifers.

Dressing percent of progeny carcasses was not influenced by cow weight, milk yield or cow fatness. Angus and Simmental sired calves had similar carcass dressing percents while there was also no difference between steers and heifers. Dressing percent is a much overrated carcass variable which is mainly influenced by gutfill and carcass fatness (Berg and Butterfield, 1976). It is thus not surprising that no differences were found in dressing percent, as progeny were slaughtered at similar fatness and under the same conditions.

Marbling score in progeny carcasses was not influenced by cow weight, milk yield or cow fatness. Other studies (Hedrick *et al.*, 1970; Koch *et al.*, 1976) have generally found lower marbling scores when European breeds were compared to British breeds, but the comparisons were not made at the same carcass fatness. Marbling is still considered an important trait in North American

markets, but can only be obtained to visible levels in fat carcasses. Other regressions involving meat colour, meat texture and meat firmness were not significant. It can safely be concluded that cow factors have no effect on these variables of subjective judgement when measured in their progeny.

The effects of cow size, milk yield and cow fatness on carcass tissue yield in the carcasses of their progeny is shown in Table 2. A 100 kg increase in cow weight gave progeny with 14 kg increase in lean tissue, 1.8 kg increase in fat and a 3.4 kg increase in bone. Young *et al.* (1978) found that larger cows gave progeny that had a higher estimated retail product although the data was adjusted to a constant slaughter age of 468 days. Koch *et al.* (1976) found no difference in retail product in carcasses produced from Angus or Hereford dams, although there is little difference in mature weight between these two breeds. Providing carcasses are at the same fatness there appears to be little inherent advantage to any dam size in terms of saleable product from progeny carcasses. Heavy or light carcasses (<200 kg and >350 kg) are often more difficult to dispose of in the North American market and generally incur discounts. Milk yield as expected had little effect on carcass tissue yields. A 1 mm in-

Table 2. Partial regressions of carcass tissue yield¹ on dam's size, milk yield and fatness, and least square means for breed of sire and sex of calf.

Dependent variable	Independent variable	Partial regression coefficient	±SE	R ²	Breed of sire least square means		Sex of calf least square means	
					Angus	Simmental	Female	Male
Lean weight (kg)	Weight of cow (kg)	0.14	0.024	0.66	66.78	86.64	73.02*	82.39
	Milk yield (kg)	0.006	0.0032					
	Cow fatness (mm)	-2.6	0.48					
Fat weight (kg)	Weight of cow (kg)	0.018	0.0072	0.42	29.24	32.12	31.25*	33.38
	Milk yield (kg)	0.006	0.001					
	Cow fatness (mm)	-0.4	0.14					
Bone weight (kg)	Weight of cow (kg)	0.034	0.002	0.67	17.81	22.57	19.12*	22.34
	Milk yield (kg)	0.002	0.0004					
	Cow fatness (mm)	-0.8	0.06					

¹Regression for muscle:bone ratio was not significant (P>0.05).

*Means for sex were all significantly different (P<0.05).

Table 3. Breed of sire and sex of calf least squares for taste panel scores¹ (0-15 cm scale).

Dependent variable	Breed of sire least square means		Sex of calf ² least square means	
	Angus	Simmental	Female	Male
Flavour	7.71	8.41	8.01	8.39
Juiciness	8.20	8.56	8.35	8.75
Tenderness	7.93	8.61	8.20	8.53
Overall acceptability	7.80	8.17	7.93	8.25
Shear force (kg)	5.03	6.13	5.47	5.48

¹Cow factors all gave a regression coefficient of zero.

²All sex means were not significant ($P>0.05$).

crease in cow fat depth (Table 2) decreased lean yield in progeny by 2.6 kg, fat by 0.4 kg and bone by 0.8 kg. The general implications are that larger cows produce larger calves which are heavier at slaughter and produce more beef. However, the effect of cow weight on progeny lean weight was not large. Large differences in tissue were noted between breed of sire and sex of calf. Cow factors (size, milk yield and cow fatness) had no effect on progeny muscle:bone ratio. Thus, size of animal *per se* does not seem to be important in the determination of muscle:bone ratio.

The effects of cow size, milk yield and cow fatness on meat quality traits of their calves are presented in Table 3. Partial regression coefficients for taste panel variables regressed on cow factors all yielded values of zero. All roasts were found to be quite acceptable by the taste panel which indicated cow factors had no measurable influence on organoleptic qualities of the progeny meat. Similar results were found by Koch *et al.* (1976), although animals were not slaughtered at constant fatness.

Conclusion

Larger cows produce cattle which are older and heavier at slaughter (Table 1), although there is no evidence from this study that cow weight had any influence on progeny meat quality (Table 3). Milk yield had little effect on carcass characteristics or meat quality (Table 2). Fat dams under a constant feeding regime tend to produce early fattening calves. Dam fatness had no effect on progeny meat quality.

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References

- Berg, R.T. and Butterfield, R.M. 1976. New Concepts of Cattle Growth. Sydney University Press, Sydney, Australia.
- Butson, S., Berg, R.T. and Hardin, R.T. 1980. Factors influencing weaning weights of range beef and dairy-beef calves. *Can. J. Anim. Sci.* 60:727.
- Harvey, W.R. 1960. Least squares analysis of data with unequal subclass numbers. United States Department of Agriculture, Columbus, OH.
- Hedrick, H.B., Lasley, J.F., Jain, J.P., Krause, G.F., Sibbett, B., Langford, L., Comfort, J.E. and Dyer, A.J. 1970. Quantitative carcass characteristics of reciprocally crossed Angus, Charolais and Hereford heifers. *J. Anim. Sci.* 31:633.
- Koch, R.M., Dikeman, M.E., Allen, D.M., May, M., Crouse, J.D. and Campion, D.R. 1976. Characterization of biological types of cattle. III. Carcass composition, quality and palatability. *J. Anim. Sci.* 43:48.
- Mandragon-Vasquez, I. 1981. Milk yield, milk composition, weight and efficiency of beef cows. M.Sc. Thesis. University of Guelph, Guelph, ON.
- Morris, C.A. and Wilton, J.W. 1976. Influence of body size on the biological efficiency of cows: A review. *Can. J. Anim. Sci.* 56:613.
- Neter, J. and Wasserman, W. 1974. Applied Linear Statistical Models. Richard D. Irwin Inc., Homewood, IL.
- Notter, D.R., Cundiff, L.V., Smith, G.M., Laster, D.B. and Gregory, K.E. 1978. Characterization of biological types of cattle. VII. Milk production in young cows and transmitted and maternal effects on preweaning growth of progeny. *J. Anim. Sci.* 46:908.
- Rutledge, J.J., Robinson, O.W., Ahlschwede, W.T. and Legates, J.E. 1971. Milk yield and its influence on 205 day weight of beef calves. *J. Anim. Sci.* 33:563.
- Smith, G.M., Laster, D.B., Cundiff, L.V. and Gregory, K.E. 1976. Characterization of biological types of cattle. II. Post weaning growth and feed efficiency of steers. *J. Anim. Sci.* 43:37.
- Spelbring, M.C., Martin, T.G. and Drewry, K.J. 1977. Maternal productivity of crossbred Angus x Milking Shorthorn cows. *J. Dairy Sci.* 59:733.
- Young, L.D., Cundiff, L.V., Crouse, J.D., Smith, G.M. and Gregory, K.E. 1978. Characterization of biological types of cattle. VIII. Postweaning growth and carcass traits of three way cross steers. *J. Anim. Sci.* 46:1178.

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Linoleic Acid Oxidation Catalyzed by Amadori Compounds in Aqueous Media

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Abstract

The present investigation was undertaken to prepare amadori substances from the reaction between various monosaccharides with amino acids to study their anti or pro-oxidant effect on linoleic acid oxidation. Aldopentoses, aldohexoses and ketohexoses showed great variation in their reactivity to form amadori substances. The pH of the reaction mixture also played an important role in some cases (DL-cysteine-HCl and L-aspartic acid) in the production of amadori compounds. The measurement of oxygen uptake of the various model systems showed that the rate of hydroperoxide formation with time was typical of an autocatalytic reaction. Considerable variation in the rates of linoleic acid oxidation in comparison with the control experiments was observed. The model systems DL-alanine/D-xylose and L-proline/D-xylose were highly antioxidative and may be applied in preserving lipids. The products of the model systems DL-cysteine-HCl/D-glucose and DL-cysteine-HCl/galactose possessed a slight antioxidant effect, while a slight pro-oxidant behaviour was observed in the model systems containing DL-cysteine-HCl with D-xylose, L-arabinose and D-fructose. No correlation was found between either the chemical structure of various amino acids and sugars, or the absorbance of the amadori solutions, and the antioxidant behaviour.

Résumé

Le but de la présente étude a été de préparer des substances amadori par la réaction entre divers monosaccharides avec des acides aminés afin d'étudier leur effet anti ou pro-oxydant sur l'oxydation de l'acide linoléique. On a observé de grandes variations entre les aldopentoses, les aldohexoses et les kétohexoses dans leur réactivité pour la formation de substances amadori. Le pH du milieu aussi joue un rôle important dans quelques cas (DL-cystéine-HCl et acide L-aspartique) pour la production de substances amadori. Tel que démontré par l'absorption d'oxygène des différents systèmes modèles, le taux de formation d'hydroperoxydes avec le temps fut typique d'une réaction autocatalytique. On a observé une variation considérable dans les taux d'oxydation de l'acide linoléique par rapport aux expériences témoins. Les systèmes modèles DL-alanine/D-xylose et L-proline/D-xylose furent très anti-oxydants et peuvent être appliqués à la conservation des lipides. Les produits des systèmes modèles DL-cystéine-HCl/D-glucose et DL-cystéine-HCl/galactose eurent un faible effet antioxydant, tandis que le système modèle à base de DL-cystéine-HCl avec du D-xylose de l'L-arabinose et du D-fructose eût un comportement faiblement pro-oxydant. On n'a observé aucune relation entre soit la structure chimique de divers acides aminés, de sucres ou l'absorbance des solutions amadori, et le comportement antioxydant.

Introduction

The interaction between sugars and amino acids is one of the chemical reactions leading to the formation of the amadori products (Maillard, 1912). This reaction involves condensation, dehydration, fission and polymerization. The result of this complicated reaction is a variety of byproducts, i.e., intermediates and brown pigments termed melanoidins which may contribute to flavour, aroma and colouring in food processing (Abdel-Akher *et al.*, 1966; Agarwal *et al.*, 1974). Autoxidation of the unsaturated fatty acids is a problem in a wider sense in the industries dealing with fats and oils because it leads to the development of rancidity and undesirable flavours. Hence, there has been an emphasis on discovering substances which can suppress the lipid oxidation. Of these investigated, propyl gallate, butylated hydroxytoluene (BHT) and butylated hydroxyanisole (BHA) have been most effective in preventing lipid deterioration. However, these synthetic substances have some deleterious effect, especially if they are present in excessive amounts.

The trend in recent years has been to use natural compounds as food additives (El-Wakeil *et al.*, 1978). In this respect, the amadori substances seem to be highly desirable since they can be prepared from natural products. There exist some contradictory data concerning the influence of various amadori materials on lipid oxidation. It has been mentioned that these compounds exhibited both antioxidant and pro-oxidant effects (Anderson and Huntley, 1964; Itoh *et al.*, 1975). The present study has been conducted to evaluate the influence of amadori substances obtained from the reaction between aldopentoses, aldohexoses or ketohexoses with various amino acids on the oxidation of linoleic acid in aqueous media.

Materials and Methods

Reagents

Linoleic acid and various amino acids and monosaccha-

rides were all analytical grade. These substances gave only one spot by thin layer chromatography (TLC) and were practically free from Cu, Fe, Co, Ni and Mn (<0.05 ppm).

Apparatus

Trace metal analysis was performed using a Pye Unicam model SP 1900 atomic absorption spectrophotometer, and pH values of the linoleic acid emulsion catalyzed by amadori solutions were measured using a pH meter. A Pye Unicam double beam recording spectrophotometer model SP 1800 was used for the estimation of the colour intensity of various stock amadori solutions. A Warburg manometric apparatus was used for measurement of oxygen uptake.

Preparation of Amadori Substances (2.4×10^{-4} M)

Amadori substances were obtained from the reaction between reducing sugars and various amino acids. Equimolar ratios of various sugars (0.005 M) and various amino acids (0.005 M) were mixed for 5 min using a Vortex shaker. Deionized water was added to bring the moisture content of the mixture to 25% (w/w), and the tubes were shaken for 5 min using a Vortex shaker. The tubes were sealed and heated in a water bath for 2 h at $80^\circ\text{C} \pm 1^\circ\text{C}$. After cooling, the contents were dissolved by bringing the volume to 25 mL with deionized water.

Preparation of Linoleic Acid Emulsion (10^{-2} M)

A mixture consisting of linoleic acid (0.706 g) and Tween 20 (0.2 mL) was made up to 25 mL with deionized water. Emulsification was achieved by agitation using a Vortex shaker for 15 min. Aliquots (0.2 mL) of this emulsion were quantitatively transferred into Warburg flasks and diluted to 2 mL with deionized water. The amadori solutions were added to the reaction mixture in 0.1 mL portions of working stock solution to give a final concentration of 10^{-5} M.

Measurement of Oxidation

Experiments were conducted at 50°C with a constant rate of 80 oscillations/min for the periods of the experiment. A minimum of three Warburg flasks containing emulsified linoleic acid, catalyzed with amadori materials, were run against appropriate controls (flasks containing emulsified linoleic acid and amadori solutions). No appreciable oxygen uptake was recorded for the controls containing just amadori solutions. If the difference in the oxygen uptake value at any stage between either the higher or the lower value over the medium value was more than 5%, the experiment was repeated. The resulting oxygen uptake data were the average value of three replicates of each experiment.

Determination of Induction Period

The induction periods of various model systems were determined by drawing two tangents along the curves corresponding to the initiation and propagation stages of linoleic acid oxidation.

Results and Discussion

Oxidation of lipids in aqueous emulsion is of considerable relevance to the deterioration of many foods, in particular milk and dairy products. A number of restric-

tions were imposed in the present work, including the concentration of linoleic acid; sugar or amino acid; type of media (aqueous); the reaction conditions for producing the amadori substances; and the type and concentration of emulsifier, as well as the temperature and shaking rate of the reaction vessels. These, together with scrupulous avoidance of contamination by extraneous metal ions and careful adherence to the routine preparation of the emulsions, produced reproducible and consistent results. The variables in the model systems were restricted only to the type of amino acids or sugars; and no buffers were used for the preparation of the model systems, since the results of Wills (1965), Haase and Dunkely (1969) and Allen *et al.* (1979) have shown that phosphate, tris and borate buffers affected the rate of lipid oxidation.

Amadori Substances

Amadori substances were prepared from the reaction between five different reducing sugars and sixteen amino acids. In order to obtain information about the reactivity of each reducing sugar with various amino acids, the absorbance at 490 nm of the reaction mixture was measured; the results are shown in Table 1. Generally, pentoses such as D-xylose and L-arabinose showed greater reactivity to produce brown colour relative to aldohexoses. This greater reactivity may be due to the ease of furfural formation. Similar findings were reported by Yuichiro (1972), where pentoses were found to be more efficient than hexoses in producing amadori substances. D-xylose gave a more intense brown colour compared to L-arabinose, except in the case of L-proline. It is worth noting that L-aspartic acid and L-leucine gave the lowest absorbance values with all other sugars relative to the other amino acids. It was noted with aldohexoses and ketohexoses that there was a great variation in their reactivity to form amadori substances. D-fructose showed a relatively higher reactivity in producing the amadori materials with most amino acids. Among the different amino acids, L-arginine and L-lysine gave the greatest intensity with all sugars.

It seems that the number of carbon atoms in the skeleton of various amino acids had a remarkable influence on the intensity of the brown colour. For instance, lysine (six carbon atoms), with a straight chain, gave a higher intensity, while leucine and valine (five carbon atoms), with a branched chain, gave generally a lower colour intensity. Such results are in agreement with those reported by Lento *et al.* (1958), who found that amino acids with six carbon atoms gave a higher colour intensity.

It seems also that the pH of the reaction mixture played an important role in some cases (DL-cysteine-HCl and L-aspartic acid). Isbell and Frush (1958) reported that the pH highly influenced the course of the reaction. It is well known that the initial step in the Maillard reaction is the reaction between the nonprotonated amino group of the amino acid and the carbonyl group of the sugar. The nucleophile (R-NH_2) by which the reaction begins is converted in acid condition to an unreactive species (R-NH_3^+). For this reason the rate of the reaction has a maximum at a moderately acid pH and falling down at each side. Such a phenomenon was observed in the present systems where the brown colour was faded at

Table 1. The absorbance and pH of solutions obtained from the reaction between various amino acids and monosaccharides.

Amino acid	D-xylose		L-arabinose		D-fructose		D-glucose		D-galactose	
	A ¹	pH	A	pH	A	pH	A	pH	A	pH
DL-alanine	1.71	4.03	1.69	4.50	1.05	4.23	0.33	5.72	0.47	5.21
L-arginine	1.71	6.56	1.69	6.79	1.70	6.95	1.69	7.36	1.69	6.44
L-aspartic acid	0.42	3.11	0.39	3.12	0.60	3.08	0.29	3.06	0.31	3.15
DL-cysteine-HCl	1.21	1.96	1.24	1.93	1.68	1.95	0.48	1.91	0.35	1.99
DL-glutamic acid	1.70	3.13	1.52	3.23	0.37	3.20	0.55	3.32	0.51	3.26
glycine	1.68	3.34	1.70	3.39	0.96	4.73	1.69	3.89	1.69	3.73
L-histidine	1.69	5.40	1.69	5.71	0.61	6.77	1.64	6.31	1.69	5.92
L-leucine	0.55	4.29	0.47	4.66	0.64	4.96	0.30	5.39	0.40	4.91
L-lysine-HCl	1.71	3.00	1.69	2.99	1.53	4.07	1.68	3.72	1.70	3.48
L-methionine	1.70	4.14	1.68	4.41	0.61	4.96	0.26	5.13	0.35	4.94
DL-β-phenylalanine	1.40	3.62	0.75	4.27	0.67	5.11	0.30	5.22	0.39	4.86
L-proline	1.40	4.06	1.58	3.95	0.42	4.89	0.58	5.02	0.55	4.58
DL-serine	1.70	4.02	1.68	4.02	0.52	3.93	0.30	5.33	0.32	5.28
DL-threonine	1.71	3.55	1.69	3.66	0.54	4.81	0.55	4.43	0.55	4.48
DL-tryptophan	1.14	3.41	1.19	4.04	1.20	4.76	1.00	5.27	1.18	5.00
D-valine	1.64	4.56	1.32	4.67	0.63	5.40	0.30	5.28	0.36	5.15

¹Absorbance was measured at 490 nm.

pH lower than three, as shown in the case of DL-cysteine-HCl (pH>2) and L-aspartic acid (pH>3). It is worth mentioning that the branched amino acid (L-leucine), in spite of its moderate pH (5.3), showed a relatively low absorbance. This might be due to the steric effect of the branched molecule, although this fact was not observed in the case of D-valine, where it showed a more intense brown colour. It seems that the inductive effect of the CH₃ group may play a certain role in the case of branched amino acids when they react with sugars.

Stability of Linoleic Acid in Aqueous Media

The model system consisting of linoleic acid (10⁻² M) and Tween 20 (0.2%, v/v) had an induction period of 22-26 h. The difference in the induction periods stems from the different linoleic acid batches. Linoleic acid used in the present investigation contained some trace metals, which certainly promote linoleic acid oxidation.

The Effect of Amadori Substances on Linoleic Acid Oxidation

The object of these experiments was to evaluate the specific anti or pro-oxidative behaviour of the amadori

substances on linoleic acid oxidation. The effect of these substances in all model systems of aqueous media has shown a feature of an autocatalytic chain reaction, i.e., the rate of hydroperoxide formation increased with time, and the secondary products are necessary to catalyze linoleic acid oxidation. The results of individual experiments showed considerable variations in the rates of oxidation in comparison with the control experiments. The stability and relative stability (the stability in h of the lipid materials relative to that of linoleic acid) of pure linoleic acid when mixed with amadori solutions were calculated; the results are presented in Table 2. Figures 1-5 are good examples of the type of results obtained in this study. A relative induction period value of <1 indicates a pro-oxidative effect, whereas a value of >1 indicates an antioxidative effect. The forthcoming results deal with the anti or pro-oxidant activity of the amadori solutions produced from various amino acids and a particular monosaccharide.

1. D-Xylose

The results of this set of experiments indicated that all amadori materials tested, except the products prepared

Table 2. Relative stability of linoleic acid (18:2) in the presence of browning substances.

Amino acid	Relative stability ¹				
	D-xylose	L-arabinose	D-fructose	D-glucose	D-galactose
18:2 + DL-alanine	1.90	1.19	1.44	1.12	1.30
18:2 + L-arginine	1.13	1.23	1.46	1.57	1.22
18:2 + L-aspartic acid	1.30	1.00	1.32	1.38	1.26
18:2 + DL-glutamic acid	1.27	1.00	1.19	1.50	1.24
18:2 + DL-cysteine-HCl	0.98	0.97	0.90	1.04	1.06
18:2 + glycine	1.36	1.21	1.27	1.30	1.03
18:2 + L-histidine	1.40	1.53	1.07	1.22	1.17
18:2 + L-leucine	1.08	1.39	1.29	1.14	1.14
18:2 + L-lysine-HCl	1.54	1.34	1.02	1.40	1.29
18:2 + L-methionine	1.30	1.40	1.22	1.12	1.14
18:2 + DL-β-phenylalanine	1.10	1.22	1.19	1.26	1.20
18:2 + L-proline	1.82	1.30	1.12	1.60	1.09
18:2 + DL-serine	1.07	1.36	1.73	1.45	1.15
18:2 + DL-threonine	1.17	1.32	1.18	1.64	1.08
18:2 + DL-tryptophan	1.24	1.13	1.23	1.45	1.20
18:2 + D-valine	1.47	1.16	1.24	1.18	1.20

¹Relative stability for linoleic acid (induction period = 22 h) was given a value of 1.00.

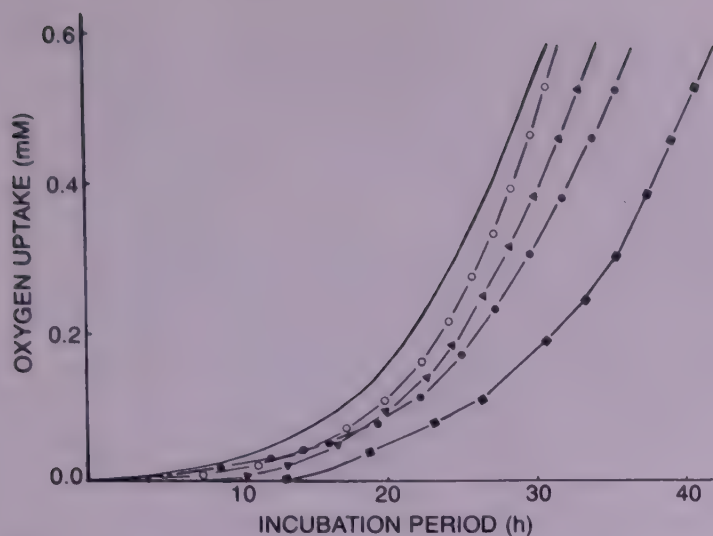


Fig. 1. Catalysis of linoleic acid (18:2) by solutions produced from the reaction of various amino acids and xylose (X). — = 18:2; —●— = 18:2 + X + tryptophan; —○— = 18:2 + X + β -phenylalanine; —▶— = 18:2 + X + leucine; —■— = 18:2 + X + valine.

from DL-cysteine-HCl, possess variable antioxidative behaviour. Similar findings were reported by Kato *et al.* (1976). Alanine and proline were the most effective amino acids in preventing linoleic acid oxidation, whereas leucine and serine were the least effective amino acids in increasing the shelf life of linoleic acid. The amadori solutions prepared from L-proline and D-xylose had an absorbance value of 1.4 with a relatively high antioxidant effect (1.82). On the contrary, the amadori products of L-arginine with D-xylose gave an absorbance value of 1.71 with a relatively low antioxidant effect (1.13). Hence, the present study suggests that there was no correlation between the colour intensity of the products formed from the reaction between reducing sugars and amino acids, and the capacity of the antioxidant effect. It has been reported that the most effective antioxidative compounds formed during the Maillard type browning reaction could not be brown coloured pigments formed during the reaction (Ckuk-In and Dong-Hoon, 1973).

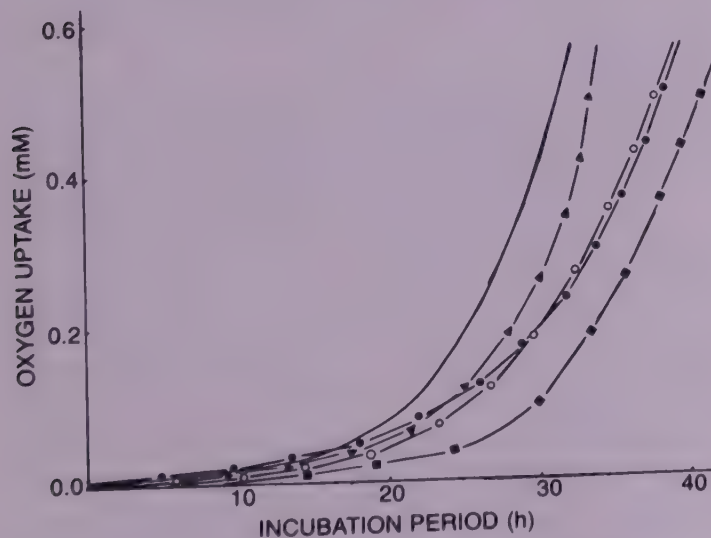


Fig. 2. Catalysis of linoleic acid (18:2) by solutions produced from the reaction of various amino acids and arabinose (A). — = 18:2; —●— = 18:2 + A + alanine; —○— = 18:2 + A + tryptophan; —▶— = 18:2 + A + β -phenylalanine; —■— = 18:2 + A + leucine.

2. L-Arabinose

The reaction products obtained from the reaction between L-arabinose and L-histidine, L-leucine, DL-serine, L-lysine, DL-threonine, L-proline, L-arginine, DL-B-phenylalanine, glycine, DL-alanine, D-valine or DL-tryptophan possessed antioxidative behaviour. Experiments with amadori solutions obtained from acidic amino acids with L-arabinose showed no anti or pro-oxidative effect on linoleic acid oxidation. Only the reaction products obtained from the model system DL-cysteine-HCl/arabinose caused a pro-oxidant activity. This model system lends weight to the results of Lewis and Wills (1962). They mentioned that the destruction rate of SH groups was considerably increased in oxygen and destroyed much more rapidly by oxidized linoleic acid emulsion than by fresh emulsion. Also, Farag *et al.* (1978) found a linear relation between concentration of hydroperoxides and the time during the first stages of linoleic acid catalyzed by cysteine. The results, in general, reflect the considerable influence of SH groups on lipid oxidation. Accordingly, one would expect that if a protein contains a high level of cysteine, it will indeed oxidize the lipid materials much faster than a protein containing low amounts of cysteine. It is worth mentioning that the results of model systems may not parallel real food systems. In general, to increase the keeping quality of lipid materials, the additive substances should not contain any compounds containing SH groups.

3. D-Fructose

The results of these experiments showed variable effects on the rates of catalyzed linoleic acid oxidation in comparison with the control experiments. All the reaction products used in this study retarded the linoleic acid oxidation, except the reaction products of DL-cysteine-HCl and D-fructose. The present data revealed that the reaction products of DL-serine, L-arginine and DL-

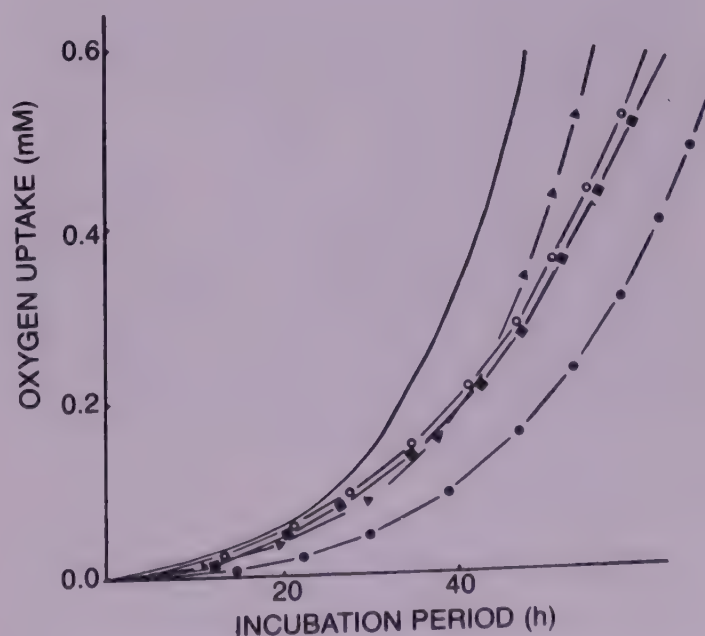


Fig. 3. Catalysis of linoleic acid (18:2) by solutions produced from the reaction of various amino acids and fructose (F). — = 18:2; —●— = 18:2 + F + tryptophan; —○— = 18:2 + F + alanine; —▶— = 18:2 + F + β -phenylalanine; —■— = 18:2 + F + leucine.

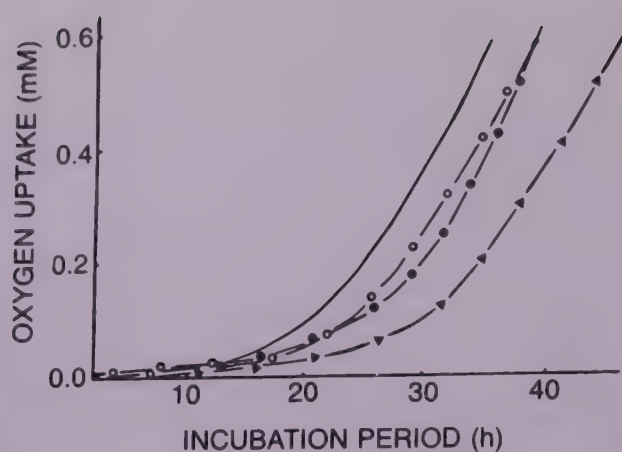


Fig. 4. Catalysis of linoleic acid (18:2) by solutions produced from the reaction of various amino acids and glucose (Gl). — = 18:2; —●— = 18:2 + Gl + glycine; —○— = 18:2 + Gl + histidine; —▲— = 18:2 + Gl + glutamic.

alanine with fructose gave the highest potency for linoleic acid protection against oxidation. On the contrary, the products of L-histidine and L-lysine with fructose showed the lowest antioxidant behaviour. Also, one can observe that most of the other model systems gave approximately similar antioxidant activities compared with linoleic acid alone. Although the products of the reaction between DL-serine and D-fructose gave the highest antioxidant activity, their absorbance was relatively low. Therefore, one would expect that some active compounds may be colourless.

4. D-Glucose

Table 2 shows the relative stability of linoleic acid oxidation in aqueous emulsion against model systems containing amadori substances and linoleic acid. Great variations in the antioxidant activities of the tested amadori solutions were found. All reaction products possessed antioxidant behaviour except the model system containing DL-cysteine-HCl. The antioxidant potency of the amadori substances can be arranged in descending order as a function of the amino acid used: threonine > proline > arginine > glutamic acid > tryptophan = serine > lysine-HCl > aspartic acid > glycine > phenylalanine > histidine > valine > leucine > alanine = methionine > cysteine-HCl. The reaction products of the system DL-cysteine-HCl/D-glucose showed a slight antioxidant effect. This phenomenon parallels the optical density of the reaction products (0.48). The low reactivity of DL-cysteine-HCl with D-glucose may hinder the formation of such products in the reaction mixture which cause the slight oxidation of linoleic acid.

5. D-Galactose

The effect of the products obtained from the reaction of D-galactose with different amino acids on linoleic acid stability was investigated, and the results are presented in Table 2. All the reaction products of the various model systems exhibited an antioxidant capacity towards linoleic acid oxidation. The highest antioxidant effects in this set of experiments were given by L-lysine, DL-alanine and L-aspartic acid. The lowest antioxidant effect was obtained from the products of D-galactose/

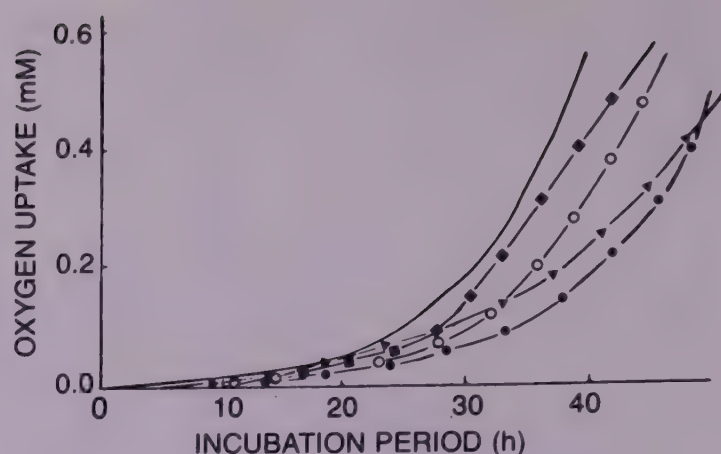


Fig. 5. Catalysis of linoleic acid (18:2) by solutions produced from the reaction of various amino acids and galactose (Gal). — = 18:2; —●— = 18:2 + Gal + alanine; —○— = 18:2 + Gal + tryptophan; —■— = 18:2 + Gal + β -phenylalanine; —▲— = 18:2 + Gal + leucine.

glycine reaction. Here again, the model system DL-cysteine-HCl/D-galactose showed very little antioxidant effect. The relative stability of the model systems DL-cysteine-HCl/D-galactose and L-aspartic acid/D-galactose was 1.06 and 1.26, respectively. The optical density for these model systems was 0.35 and 0.31, respectively. Therefore, no correlation could be established between the absorbance of the amadori solutions and their antioxidant effects.

Generally, under the experimental conditions, the effect of amadori solutions obtained from the reaction between various reducing sugars and amino acids on linoleic acid oxidation revealed the following points. The model systems containing D-glucose or D-xylose with various amino acids exhibited the highest antioxidant effect, and may serve best in preserving lipids. On the contrary, the model systems containing various amino acids with D-galactose or D-fructose products possessed the lowest antioxidant behaviour. No direct correlation could be obtained between the chemical structure of various amino acids or sugars involved in the model systems and the corresponding antioxidant effect.

References

- Abdel-Akher, M., Loutfy, M. and Ibrahim, A. 1966. Preparation of cola-colouring substances. *Die Strake* 8:243.
- Agarwal, S.K.D., Johary, P.C. and Misra, D.S. 1974. Infrared spectroscopic studies on different constituents of sugar colourants as obtained by paper chromatographic elution and on dialysis. *Z. Zucherind* 24:532.
- Allen J.C., Farag, R.S. and Crook, E.M. 1979. The metal-catalyzed oxidation of aqueous emulsions of linoleic acid and trilinolein. *J. Appl. Biochem.* 1:1.
- Anderson, R.H. and Huntley, T.E. 1964. Pro-oxidant effect of some carbonyl compounds in vegetable oils. *J. Am. Oil Chem. Soc.* 41:686.
- Ckuk-In, H. and Dong-Hoon, K. 1973. Antioxidant activity of some extracts from various stages of a Maillard-type browning reaction mixture. *Han'guk Sikpum Kwahakhoe Chi* 5:84.
- El-Wakeil, F., Morsi, M.K.S., Farag, R.S. and Hallabo, S.A.S. 1978. The antioxidant effect of naturally occurring unsaponifiable matter in linoleic acid and some vegetable oils. *Grasas Aceites* 29:9.
- Farag, R.S., Osman, S.A., Hallabo, S.A.S. and Nasr, A.A. 1978. Linoleic acid oxidation catalyzed by various amino acids and cupric ions in aqueous media. *J. Am. Oil Chem. Soc.* 55:703.

- Haase, G. and Dunkely, W.L. 1969. Ascorbic acid and copper in linoleate oxidation. I. Measurement of oxidation by ultraviolet spectrophotometry and the thiobarbituric acid test. *J. Lipid Res.* 10:555.
- Isbell, H.S. and Frush, H.L. 1958. Mutarotation, hydrolysis and rearrangement reactions of glycosylamines. *J. Org. Chem.* 23:1309.
- Itoh, H., Kawashima, K. and Chibata, I. 1975. Antioxidant activity of browning products of triose sugar and amino acid. *Agric. Biol. Chem.* 39:283.
- Kato, H., Horie, T. and Fujimaki, M. 1976. Antioxidant activity of the browning oils prepared from D-glucose and L-leucine and its synergism with tocopherol. *Eiyo To Shokuryo* 29:179.
- Lento, H.G., Jr., Underwood, J.C. and Willits, C.O. 1958. Effect of the position of amino group in the acid molecule in dilute glucose solutions. *Food Res.* 23:68.
- Lewis, S.E. and Wills, E.D. 1962. Destruction of sulfhydryl groups of proteins and amino acids by peroxides of unsaturated fatty acids. *Biochem. Pharmacol.* 11:901.
- Maillard, L.C. 1912. Action of amino acids on sugars. Formation of melanoidins in a methodical way. *Compt. Rend.* 154:66.
- Wills, E.D. 1965. Role of metals and hematin proteins in the catalysis of the oxidation of unsaturated fatty acids. *Biochem. Biophys. Acta* 98:238.
- Yuichiro, T. 1972. Antioxidant activity of amino-carbonyl reaction products. (3) Antioxidant activity of the reaction products of various sugars or aldehydes with tryptophan. *Kagoshima Daigaku Nogabuku Gakujutsu Hokoku* 22:99.

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Recovery of Whey Proteins from Concentrated Sweet Whey

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Abstract

Effects of pH, heat treatment, concentration of solids and mechanics of processing on separation of proteins from whey concentrated by reverse osmosis were studied. Acidification of whey to yield a protein concentrate of pH less than 5.5 decreased protein recovery in laboratory experiments, but increased recovery of protein in pilot plant experiments. Ash content of heat precipitated whey proteins decreased with acidification. Maximum protein recovery was obtained by heating to 95°C for 5 min before acidification with citric acid and drainage through 16 mesh/cm metal screen. Whey from the manufacture of 10 kg of semisoft cheese of 49% moisture yielded 8 kg protein concentrate.

Résumé

On a étudié les influences du pH, du traitement thermique, de la concentration en extraits secs et des moyens de transformation sur la séparation des protéines de lactosérum concentré par osmose inverse. L'acidification du lactosérum pour obtenir un concentré protéique au pH inférieur à 5,5 a diminué la récupération des protéines dans des essais de laboratoire mais l'a augmenté dans des essais à l'échelle semi-industrielle. La teneur en cendres des protéines de lactosérum précipitées à la chaleur a diminué avec l'acidification. La récupération maximum des protéines a été obtenue en chauffant à 95°C pendant 5 min avant l'acidification à l'acide citrique et en drainant à travers un tamis métallique de 16 mailles/cm. Le lactosérum produit lors de la fabrication de 10 kg de fromage semi-dur de 49% d'humidité a donné 8 kg de concentré protéique.

Introduction

Recovery of heat precipitated whey proteins (HPWP) from whey has been reviewed recently (Hill *et al.*, 1982). HPWP is defined here as whey protein concentrate produced by heat- or heat/acid-precipitation from sweet or acid whey. The application of reverse osmosis (RO) to whey processing has made it possible to concentrate whey with low energy requirements. One Canadian cheese plant has reported the concentration of 45,000 kg whey daily by RO (J. Duckworth, personal communication). In our study, recovery of HPWP from reverse osmosis-concentrated whey (ROCW) was investigated. Effects of pH, heat treatment, concentration and mechanics of processing whey on the recovery of HPWP from ROCW were studied.

Materials and Methods

Laboratory Experiments

Six kg and 20 mL lots were used in laboratory experiments. A single lot of reconstituted whey powder was used with 20 mL lots to eliminate variability of ROCW supply. Whey powder was manufactured from cheddar whey by evaporation and spray drying. The effect of whey solids on buffer capacity (BC) of reconstituted whey was determined by titrating 15 g samples containing 8, 12, 16, 20 and 24% total solids with a 10% solution (w/w) of citric acid monohydrate (CAM). The relationship of BC to % whey solids was interpreted in two ways: BC1 was based on weight of reconstituted whey and BC2 was based on weight of whey solids. In equation form:

$$BC1 = \text{weight CAM/weight of whey} \quad (1)$$

$$BC2 = \text{weight CAM/weight of whey solids} \quad (2)$$

Effects of temperature and acidity on the recovery of solids from reconstituted whey were measured using 15 g samples of 16% reconstituted whey. HPWP was precipitated at 82.5 and 95°C at each of four levels of CAM in the range 0-1.67%. Percentage CAM is the weight of CAM/weight of whey, concentrated whey or reconstituted whey, as the case may be. The four levels of CAM were selected on the basis of preliminary experiments to give HPWP pHs of 5.9, 5.1, 4.3 and 3.5. The experiment was replicated giving a total of sixteen observations. The relationship between solids recovery and CAM was further studied using six levels of CAM in the range of 0.0-0.2%.

Six kg lots of ROCW were used to investigate effects of heating and levels of CAM on composition and recovery of HPWP. ROCW was obtained from a factory manufacturing semisoft cheese and contained about 19% total solids, 2.5% protein and 0.2% fat. Whey pH was about 6.5 before concentration and 6.2-6.3 after concentration. HPWP was separated with cotton bags (warp x filling = 40 x 40/cm). Effects of heat were determined

without additions of acid for temperatures of 82.5, 85, 90 and 95°C at each of four holding times, 0, 5, 15 and 30 min. Also, effects of six levels of CAM in the range 0-2.3% were studied by acidifying subsequent to heating at 95°C for 10 min.

Pilot Plant Studies

HPWP was recovered from 127 kg lots of ROCW by heating it at 95°C for 10 min with or without subsequent acidification with 0.22% CAM, followed by separation on 16 mesh/cm woven screen. Whey separation was too slow when filtered with cotton broadcloth.

Commercial Studies

Studies were conducted in a dairy plant to determine the % CAM required to prepare HPWP from commercial lots of ROCW. This work was performed by plant personnel under our direction. Whey of pH 6.4-6.5 was concentrated by RO to varying levels of solids ranging from single strength whey to 22%. The amount of CAM required to acidify each sample to pH 5.5 was then determined.

Analytical Methods

A Fisher Acumet pH meter, Model 310, equipped with the standard Fisher combination electrode, was used. Moisture was determined by drying for 24 h at 105°C in a forced air oven. HPWP fat and protein were determined by blending 20% (w/w) HPWP in 10% (w/v) sodium citrate in a high speed mixer followed by homogenization in a Foss laboratory homogenizer. Fat was determined by the Mojonnier method (Mojonnier Bros. Co.) and protein by the semi-microKjeldahl method (protein = N x 6.38). Protein recovery was reported as percent recovery of the total nitrogen content of ROCW. Yields and recoveries were calculated as weight of the component in the HPWP divided by the weight of the component in ROCW.

Statistical Analyses

Data were analyzed by regression or analysis of variance (ANOVA). Planned contrasts were used with ANOVA to identify different means. Highly significant and significant results indicate $P < 0.01$ and $P < 0.05$, respectively.

Results and Discussion

Laboratory Studies

The titration of whey or reconstituted whey with CAM results in a tertiary relationship between % CAM and whey pH (Figure 1). The relationship between BC1 and % whey solids was positive and linear (Equation 3).

$$BC1 = 0.08675(\% \text{ solids}) + 0.286 \quad (3)$$

$$r = 0.999, P < 0.01$$

However, the regression of BC2 on whey solids concentration was negative and quadratic; i.e., BC/weight of whey solids decreased with increasing concentration of whey solids (Figure 2). This result indicated that the amount of acidulant required per unit weight of whey solids decreased with increasing concentration of whey solids. The negative relationship between BC2 and % whey solids was supported by the observation that pH of milk or whey decreased with increasing solids. Because addition of solids lowered the pH before acid titration, the amount of acid (per weight of whey solids) required

to lower the pH to 3.5 also decreased. The exact relationship of % solids to whey pH for reconstituted whey powder used in this work is shown in Figure 3.

Effects of various combinations of temperature and acid on the recovery of solids from 16% reconstituted whey were studied. ANOVA indicated highly significant effects of temperature and acid on recovery of solids. Mean recovery of solids at 82.5 and 95°C were 26.14 and 29.39, respectively. The mean difference was 3.25 with a standard error (SE) of 0.59. The relationship between % CAM and solids recovery was negative and quadratic ($P < 0.01$). The means ranged from 31.98 with 0% CAM to 25.78 with 1.7% CAM. The linear and quadratic coefficients were -15.68 and 7.5, respectively, and their standard errors (with 8 df) were 3.32 and 1.86, respectively. Therefore, the best treatment with respect to solids recovery was 95°C with no added acid.

There was also a highly significant interaction effect

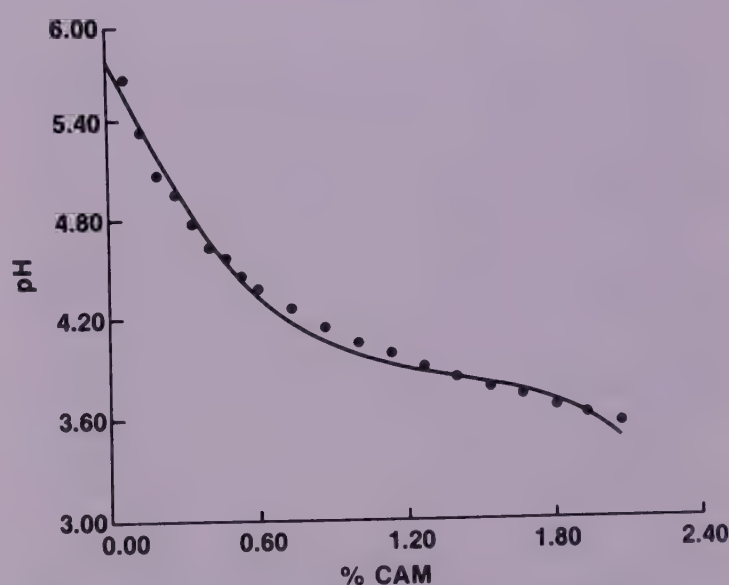


Fig. 1. pH of 20% reconstituted whey powder vs. % CAM.
 $y = 5.75 + 3.79x + 2.63x^2 - 0.65x^3$ ($r = 0.994$, $P < 0.01$).

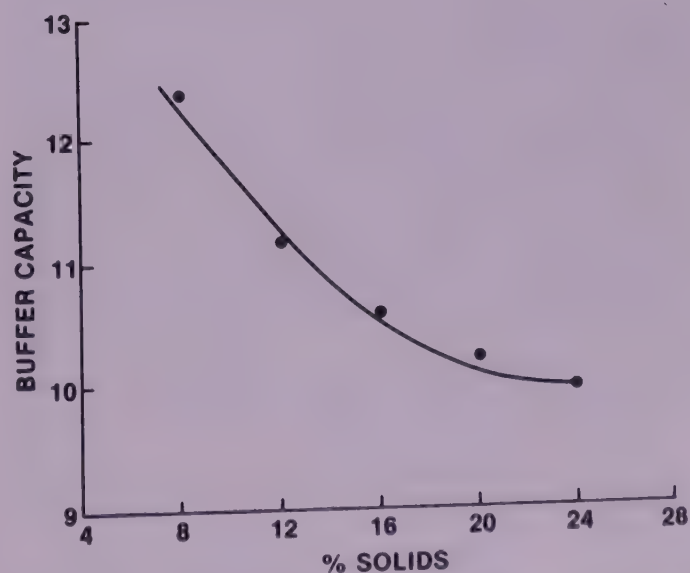


Fig. 2. Buffer capacity (BC2) of reconstituted whey powder vs. % whey solids: where BC2 is the % CAM/weight of solids required to acidify reconstituted whey to pH 3.5.
 $y = 15.186 - 0.4504x + 0.0096x^2$ ($r = 0.997$, $P < 0.01$).

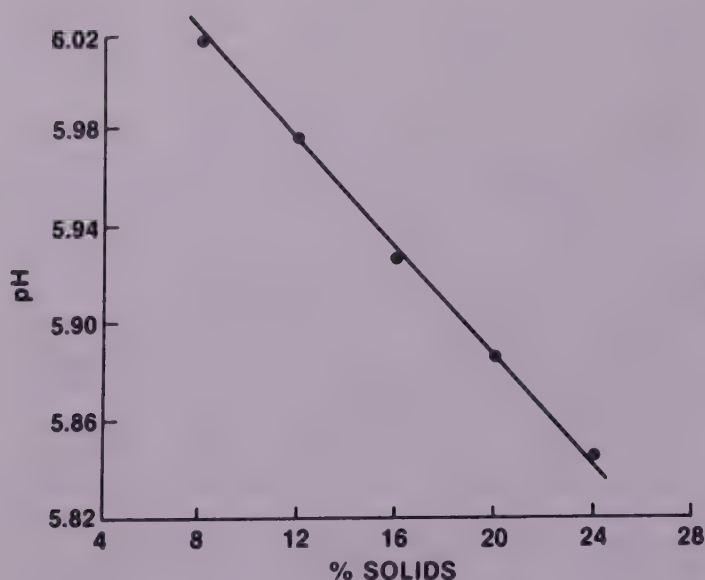


Fig. 3. pH of reconstituted whey powder vs. % solids.
 $y = 6.094 - 0.0108x$ ($r = 0.995$, $P < 0.01$).

of CAM and temperature on HPWP pH. The interaction indicates that with 0.0 and 0.13% levels of CAM, heating at 95°C decreased the pH of HPWP (Table 1). It was observed that drainage time through filter paper decreased with increasing temperature and with addition of acid. Filtrates without added acid were less turbid.

The use of six increments of CAM in the range 0.0-0.2%, with corresponding filtrate pH values of 5.7-4.9, indicated a linear relationship between % CAM and filtrate pH ($r = 0.995$, $P < 0.01$). The relationship between % CAM and the recovery of solids was curvilinear and confirmed earlier results which indicated higher recovery of solids without added acid (Figure 4). Although the relationship was significant, the low correlation coefficient ($r = 0.738$) indicated the presence of other variables which affected solids recovery. Experiments with 6 kg samples also confirmed this relationship. Protein recoveries ranged from 55.7-43.0% with increasing CAM in the range 0-2.3% and HPWP pH in the range 5.63-3.52 (Figure 5). The relationship between HPWP pH and ash content for 6 kg lots was positive and curvilinear (Figure 6). This relationship was supported by the literature which reported higher ash content for acid whey than for sweet whey (Mavropoulou and Kosikowski, 1973). HPWP moisture decreased linearly from 70-53% as pH decreased to about 4.5 (Figure 7). This value was in the range reported for the isoelectric point of the principal whey proteins (Gordon, 1971; McKenzie, 1971). As HPWP pH decreased below 4.5-3.5, lactalbumin moisture increased linearly back to 70%. Addition of acid also

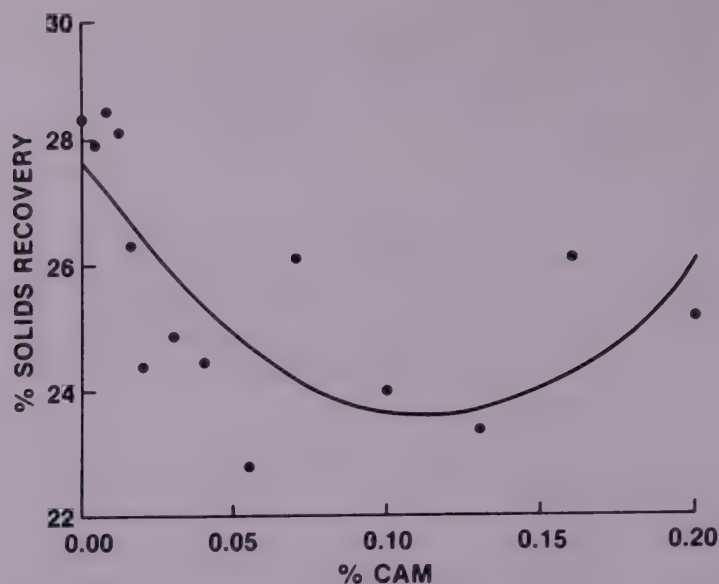


Fig. 4. % solids recovery from 16% reconstituted whey powder vs. % CAM.
 $y = 27.57 - 74.0x + 331.1x^2$ ($r = 0.738$, $P < 0.05$).

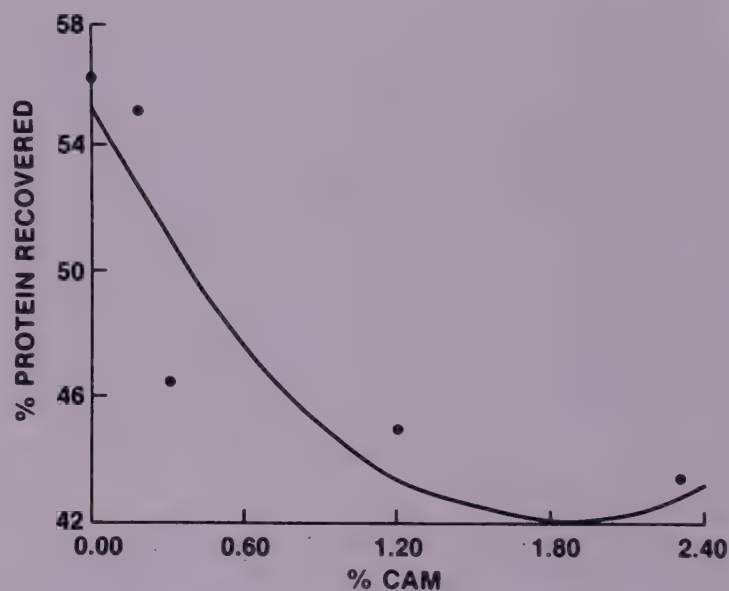


Fig. 5. Protein recovery from ROCW of 20% solids vs. % CAM.
 $y = 55.024 - 14.980x + 4.156x^2$ ($r = 0.88$, $P < 0.01$).

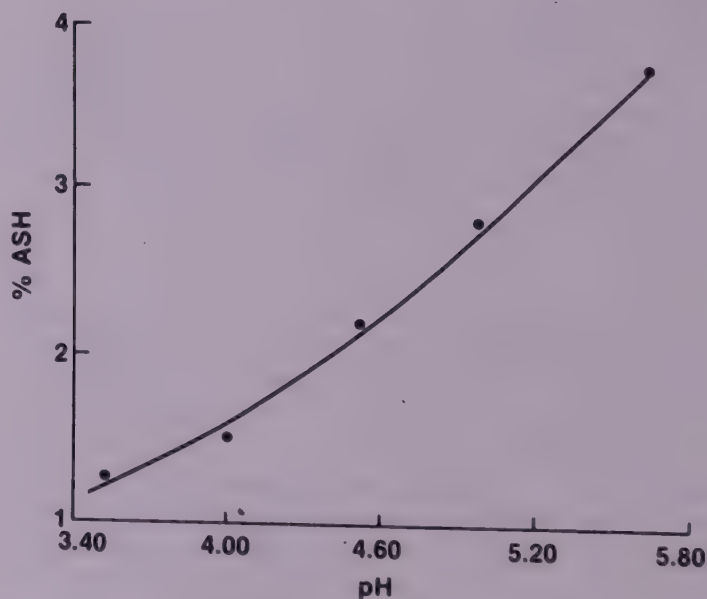


Fig. 6. Ash content vs. pH of heat precipitated whey protein.
 $y = 1.478 - 0.904x + 0.230x^2$.

Table 1. Interaction effect of temperature and CAM on the pH of HPWP: Table of means and differences.

% H CAM	Temperature (°C)		Difference ¹
	82.5	95	
0.00	5.68	5.55	0.13
0.13	5.10	5.01	0.09
0.47	4.31	4.30	0.01
1.67	3.49	3.47	0.02
Overall mean	4.64	4.58	0.06

¹SE of differences = 0.017 with 8 df.

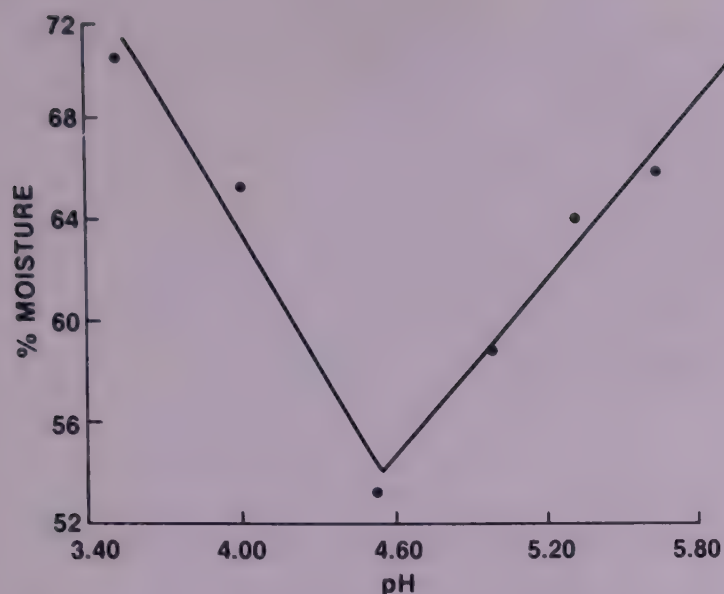


Fig. 7. Moisture vs. pH of heat precipitated whey protein.

In the pH range:

3.5-4.5; $y = 132 - 17.40x$ ($r = 0.978$, $P < 0.01$).

4.5-5.6; $y = -1.7 + 12.102x$ ($r = 0.989$, $P < 0.01$).

affected HPWP texture. Graders indicated decreased chalkiness and graininess with decreased pH. Below pH 4.5 the HPWP was smooth and spreadable. This texture change may be as much related to ash content as to pH.

Effects of heating on HPWP composition and protein recovery were studied using 6 kg lots of ROCW. Observation indicated an obvious effect of heating on the degree of protein aggregation. Heating at 82.5°C for 0 or 5 min produced a fine precipitate which clogged the cloth filters and prevented drainage. ROCW heated at 82.5°C for 15 or 30 min drained slowly. Therefore, all treatments at 82.5°C were eliminated from the experimental analysis. Significant effects are listed below.

- (1) Effect of temperature on moisture content of HPWP
Mean moisture content (four observations/mean) decreased from 70.6% at 85°C to 65.5% at 95°C. The linear component was highly significant. The slope and its SE (6 df) were -0.50975 and 0.0972 , respectively.
- (2) Effect of temperature on pH of HPWP
Mean HPWP pHs (four observations/mean) were 5.67, 5.44 and 5.41 at 85, 90 and 95°C, respectively. The means at 90 and 95°C were compared to the mean at 85°C (Snedecor and Cochran, 1980). The mean difference (0.245) was highly significant (SE = 0.0122 with 6 df).
- (3) Effect of temperature on protein recovery
Mean recoveries of protein (four observations/mean) increased from 44.75% at 85°C to 48.55% at 95°C. The linear component was highly significant. The slope and its SE (6 df) were 0.3798 and 0.1053 , respectively.
- (4) Effect of holding time on protein recovery
Mean recoveries of protein (three observations/mean) were 44.53, 48.23, 47.29 and 48.02 at 0, 5, 15 and 30°C, respectively. The mean at zero holding time was compared to the other three means. The mean difference (3.32) was significant at the 90% level (SE = 0.993 with 6 df).

There is also an apparent interaction effect of tempera-

ture and holding time on protein recovery, but lack of replication prevents a positive conclusion. It is believed that the optimum heat treatment with respect to protein recovery is 95°C for 5 min. The positive effect of temperature on protein recovery confirms the studies using 20 mL lots, which indicated increased recovery of solids with increased temperature.

Pilot Plant Studies

HPWP composition and recovery of solids, fat and protein for two lots of ROCW are shown in Table 2. These results indicated higher % recoveries of total solids when whey was acidified to pH 5.35 by addition of 0.22% CAM and filtered on woven wire screen. This was not in agreement with laboratory experiments in which maximum recovery of solids occurred without addition of acid. There are two possible reasons for the contradiction of solids recoveries with acidification. First, the difference may be due to the mechanics of processing. In laboratory experiments, filter paper or cloth was used to remove efficiently the precipitated curd, whereas in the larger lots some fine precipitate passed through the screen into the filtrate. The addition of acid encouraged the formation of larger curd particles which were more readily retained on the screen. Also, it has been observed during the manufacture of traditional ricotta cheese that a second "rise" of curd occurred after acidification to about pH 5.5 (Hill *et al.*, 1982). The other possible reason is that interactive effects of heat and acid introduced other variables which were not recognized. Further experiments with larger lots of ROCW indicated that acidification to 5.5, subsequent to heating, was sufficient to facilitate separation on wire screen.

Commercial Studies

The pH of ROCW at room temperature was always the same as the final pH of the HPWP made from it. This suggested that if 0.2% CAM, for example, was required to acidify the whey to pH 5.5 at room temperature, this amount of acid when added to the hot whey would produce HPWP with pH 5.5. To test this hypothesis, the amount of CAM required to reduce the pH to 5.5 was determined for each of twenty-five samples of ROCW. The relationship between the % CAM required for HPWP recovery at pH 5.5 and ROCW solids is shown in Figure 8. The relationship between whey solids and pH, which was established in laboratory studies (Figure 3), was

Table 2. Composition and yield data for lactalbumin precipitated from concentrated whey of 20% total solids with 0.00 and 0.22% CAM.

	Lot #	
	2	3
% CAM	0.00	0.22
Curd pH	5.95	5.35
Curd composition: moisture	64.14	60.48
fat	1.93	2.07
protein	18.17	21.86
% Lactalbumin yield	7.36	7.21
Recovery of solids	12.92	13.16
fat	74.06	81.01
protein	50.67	62.17
% Whey filtrate solids	19.24	18.96

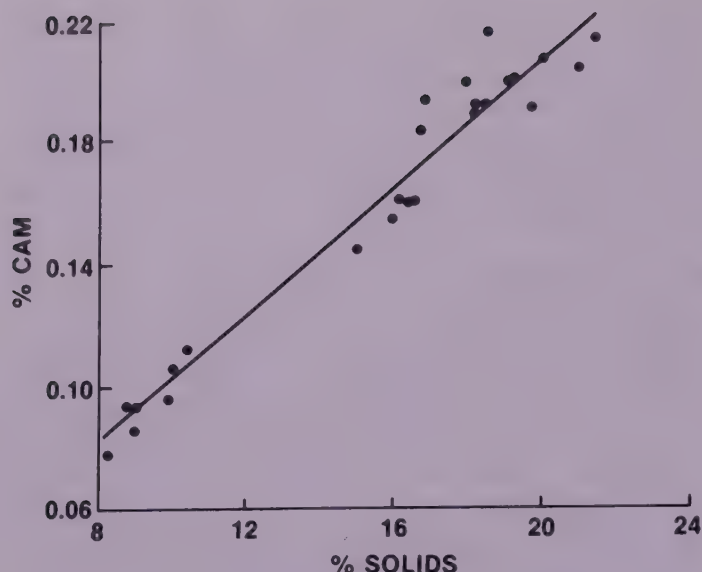


Fig. 8. % CAM recommended for recovery of protein from ROCW vs. whey solids (commercial data).
 $y = -0.0042 + 0.0136x$.

confirmed by commercial data (Figure 9). There was also a linear relationship between the pH of ROCW and required % CAM for HPWP recovery (Equation 4).

$$\text{required \% CAM} = -0.4956(\text{whey pH}) + 3.288 \quad (4)$$

$$r = 0.977, P < 0.01$$

It should be noted that these relationships depend upon consistent processing procedures to ensure uniform pH levels in the supply of single strength whey. The relationships must be redefined for each operation.

This technology was used to produce HPWP from a 700 kg lot of 18% whey. Yield and moisture were 24 and 70%, respectively. In this particular commercial operation, yields were such that whey from each 10 kg of semi-soft ripened cheese produced 8 kg of HPWP. Total processing cost, including pasteurizing and concentration of single strength whey, was about \$0.12/kg of fresh HPWP (J. Duckworth, personal communication).

Conclusion

For maximum protein recovery, ROCW must be heated to 90°C for 5 min followed by acidification to about pH 5.5. Addition of acid promotes the formation of large curd particles and affects HPWP moisture and texture. Minimum moisture occurs at pH 4.5 and increases sharply on either side of this value. Reduction of HPWP pH from 5.8-3.5 causes its texture to change from chalky and

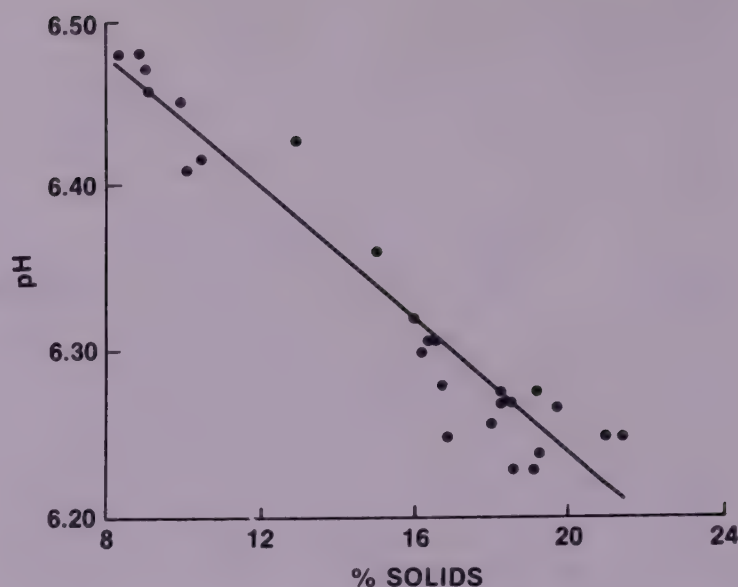


Fig. 9. pH of whey concentrated by RO vs. % solids (commercial data).
 $y = 6.631 - 0.0201x$ ($r = 0.958, P < 0.01$).

crumbly to smooth and spreadable. Increasing acid also lowers HPWP ash content. This technology of heating, acidifying and separation of ROCW is easily and economically applicable to the commercial production of HPWP.

Acknowledgement

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References

- Gordon, W.G. 1971. α -Lactalbumin. In: Milk Proteins. Volume 2. H.A. McKenzie (Ed.). p. 346. Academic Press Inc., New York, NY.
- Hill, A.R., Irvine, D.M. and Bullock, D.H. 1982. Precipitation and recovery of whey proteins: A review. Can. Inst. Food Sci. Technol. J. 15:155.
- Mavropoulou, I.P. and Kosikowski, F.V. 1973. Composition, solubility and stability of whey powders. J. Dairy Sci. 56:1128.
- McKenzie, H.A. 1971. β -Lactoglobulins. In: Milk Proteins. Volume 2. H. A. McKenzie (Ed.). p. 307. Academic Press Inc., New York, NY.
- Mojonnier Bros. Co. Instruction Manual for Setting Up and Operating the Mojonnier Milk Tester. Bulletin 101, 61. Mojonnier Bros. Co., Chicago, IL.
- Snedecor, G.W. and Cochran, W.G. 1980. Statistical Methods. Iowa State University Press, Ames, IA. Page 225.

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Niveau de contamination microbienne dans un abattoir de volailles

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Abstract

The level of microbial contamination was determined on chickens, working surfaces and water samples in a broiler plant. Samples (swabs and water) were collected at eleven different sites on the production line during ten different working days over a 12 mo period. Quality parameters evaluated were aerobic plate count at 35 and 22°C, total coliforms, fecal coliforms, streptococci, and molds and yeasts.

Total bacteria counts at 35 and 22°C varied from 6.72 to 4.54 (log 10) and 6.78 to 4.87, respectively; total and fecal coliforms varied from 3.89 to 0.90 and 1.09 to 0/77 cm² or 100 mL, respectively. Broiler cages, followed by scalding and bird chilling waters, were the most contaminated points. In the broiler plant, the total count of all microbial groups found on the chickens, the working surfaces and in the water samples increased with the production time. Finally, the total count of any microbial group evaluated was maximum during the hot summer months and minimum in January.

Résumé

Le degré de contamination microbiologique a été déterminé sur les surfaces de travail et les viandes d'une chaîne de transformation dans un abattoir de volaille ainsi que dans l'eau des refroidisseurs. Les échantillons (écouvillons et eaux) ont été prélevés à onze endroits sur la chaîne au cours de dix journées de production réparties sur une période de douze mois. La contamination a été déterminée en dénombrant les bactéries totales à 35 et 22°C, les coliformes totaux, les coliformes et streptocoques fécaux ainsi que les levures et moisissures.

Les dénombrements de bactéries totales à 35 et 22°C ont varié de 6,72 à 4,54 (log 10) et 6,78 à 4,87, respectivement; les coliformes totaux et fécaux ont varié de 3,89 à 0,90 et 1,09 à 0/77 cm² ou 100 mL, respectivement. Les cages à poulet et les eaux de l'échaudeur et du pré-refroidisseur furent les endroits les plus contaminés. Dans l'abattoir de volailles, la numération de tous les groupes microbiens dénombrés sur les surfaces de travail et de poulet ainsi que dans les eaux augmenta avec la durée de production au cours de la journée. Finalement, la numération de tous les microorganismes fut maximum au cours des mois chauds d'été et atteignit un minimum en janvier.

Introduction

Le maintien d'une hygiène convenable dans les abattoirs de volaille est très important surtout à cause de la présence fréquente de salmonelles (Simard et Auclair, 1981). De plus, le nombre de bactéries totales et de bactéries psychrophiles augmente sur les volailles en fonction de la période de production (Clark, 1965; Clark et Lentz, 1969). Plus spécifiquement, Lillard (1977) a trouvé que la réutilisation abusive des eaux des échaudeurs, des laveurs et des refroidisseurs augmentait la contamination de la surface des volailles. Récemment, Hamza et coll. (1978) ont étudié l'effet du recyclage d'eaux similaires et ils ont observé que le degré de contamination était fonction de la durée et de la réutilisation de ces eaux. Cette contamination est d'autant plus importante que la présence de 10⁶ à 10⁸ microorganismes/cm² de surface de poulet entraîne une mauvaise odeur (Green, 1974).

Très peu de travaux ont été effectués sur la détermination du degré de contamination des surfaces de travail au cours des opérations de production. Simard et Auclair (1981) ont évalué le taux de contamination microbienne sur les surfaces de travail et de viandes dans cinq établissements "Approuvé Canada." Ils ont noté que le niveau de contamination passablement élevé au début a rapidement diminué à la suite de l'implantation d'un programme d'assainissement efficace. Seulement quelques travaux ont porté sur le taux de contamination dans les abattoirs de volaille et particulièrement sur la contamination des surfaces des viandes de poulet (Clark et Lentz, 1969; Van Schothorst et coll., 1976).

A notre connaissance, aucun travail n'a été rapporté sur le cycle de contamination des surfaces de travail en fonction d'une journée de production et au cours de l'année. L'objectif de la présente étude était de mettre en évidence les endroits les plus susceptibles d'être contaminés, de même que la période de la journée où une action de

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nettoyage pourrait être efficace tout en ne modifiant pas le bon fonctionnement des opérations. Cette étude s'est échelonnée sur une période de douze mois et a permis d'établir la variation saisonnière des contaminations.

Matériel et méthodes

Ce travail a été effectué dans un abattoir de volaille "Approuvé Canada," transformant quelque 20,000 à 25,000 sujets quotidiennement et employant quelque 125 personnes. Les volailles y sont soit vendues à l'état frais, congelées ou coupées en neuf parties. Un schéma du déroulement des opérations indiquant les endroits échantillonnés est présenté à la figure 1.

Relevés sanitaires

Un total de dix relevés sanitaires ont été effectués au cours de la période de mai 1977 à mars 1978. Chaque relevé comportait cinq séries de prélèvements effectués à 7h00, 10h00, 12h00, 14h30 et 16h30. A chaque prélèvement, les mêmes endroits ont été échantillonnés (figure 1): cage à poulet (1), eau d'échaudage (2), crochets de 2e ligne (3), poulet après éviscération (4), eaux du pré-refroidisseur (5) et du refroidisseur (6), poulet frais avant emballage (7), dallot d'emballage (8), poulet dans les bassins réfrigérés (9), poulet coupé en neuf parties (10) et table de travail du poulet congelé au "Cry-O-Vac" (11).

Méthodes d'échantillonnage

Le taux de contamination des surfaces a été déterminé selon la technique de l'écouvillon telle que décrite précédemment (Simard et Auclair, 1981). Le prélèvement à l'aide d'un écouvillon genre "Q-tip" a été effectué sur une surface prédéterminée de 77 cm² (4" x 3") délimitée par un cadre métallique muni d'une poignée, lequel avait été stérilisé à la flamme avant chaque prélèvement. Pour les surfaces humides, nous avons utilisé directement l'écouvillon, tandis que pour les surfaces sèches, l'écouvillon a d'abord été humecté avec la solution stérile

servant de diluant. Après le balayage de la surface (deux fois dans deux directions à angle droit), l'écouvillon a été placé dans une bouteille contenant 100 mL d'une solution saline à 0,85% NaCl et de tween 80 à 0,1% en brisant le bâtonnet sur le bord de la bouteille. L'échantillonnage des liquides, tels les eaux d'échaudage et de refroidissement a été effectué à l'aide de bouteilles à dilution préalablement stérilisées à l'autoclave. Toutes les opérations nécessitant une stérilisation sur place ont été effectuées à l'aide d'une torche à gaz propane portable.

Pendant la période d'échantillonnage, soit de 7h00 à 16h30, les échantillons étaient conservés dans une chambre froide maintenue à 0-4°C. Le transport des échantillons entre l'usine et le laboratoire nécessitait environ 2 h, et fut effectué dans des contenants isolés permettant de maintenir une température de 0-4°C.

Analyses microbiologiques

Les méthodes d'analyses utilisées étaient celles de l'APHA (1971). Pour les bactéries aérobies totales à 35 et 22°C, la gélose pour le dénombrement sur boîtes de Petri (Plate Count Agar) a été employée et pour les coliformes totaux, la gélose à la bile rouge violet (Violet Red Bile Agar). La filtration sur membrane Millipore a été retenue pour l'essai de coliformes fécaux. Les streptocoques fécaux ont été dénombrés sur gélose pour les M-entérocoques (M-Enterococcus Agar), et les levures et moisissures sur gélose au dextrose et aux pommes de terre (Potato Dextrose Agar) acidifié à l'acide tartarique. Pour les salmonelles, les milieux suivants ont été employés successivement: pré-enrichissement dans le bouillon au tryptose laurylique (Lauryl Tryptose Broth); enrichissement dans le bouillon au sélénite et à la cystine (Selenite Cystine Broth), sélection sur gélose S.S. (S.S. Agar) et gélose entérique Hecktoen (Hecktoen Enteric Agar), et confirmation sur gélose au triple sucre et au fer (Triple Sugar Iron Agar). Par la suite, l'identification des salmonelles isolées a été effectuée aux laboratoires du ministère des Affaires Sociales du Québec à Montréal.

Analyses statistiques

Dans le texte, tous les résultats (à moins d'indications contraires) sont exprimés en logarithme (base 10) par 77 cm² (3" x 4") ou par 100 mL et représentent la moyenne de 50, 55 ou 110 observations selon les paramètres étudiés. Les analyses des moyennes, écarts-types et comparaisons multiples de ces moyennes (Duncan) ont été effectuées selon Snedecor et Cochran (1978) au Centre de Traitement de l'Information de l'Université Laval.

Résultats et discussion

Dans cette étude, plus de 550 échantillons ont été prélevés et 3,300 résultats microbiologiques ont été compilés et traités de façon à mettre en évidence le degré de contamination en fonction de la durée des opérations de la saison de prélèvement de même que des différents points stratégiques échantillonnés sur la chaîne de transformation.

Contamination au cours des opérations journalières

Les moyennes et écarts-types des divers groupes microbiens pour onze points de prélèvements effectués à cinq temps différents dans une journée pour chacun des dix

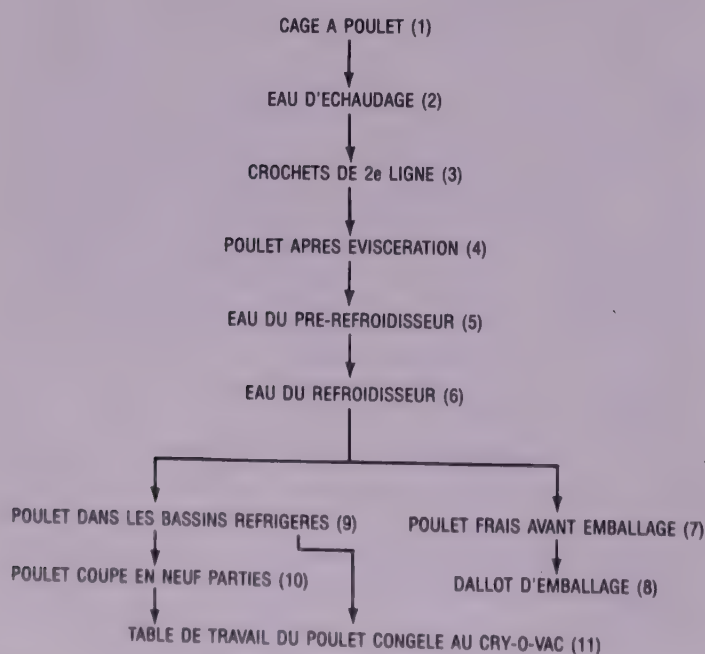


Fig. 1. Séquence d'acheminement des poulets dans l'usine d'abattage et endroits de prélèvement des échantillons.

relevés sanitaires répartis sur une période de douze mois, sont présentés au tableau 1.

On note pour les bactéries totales à 35 et 22°C, des différences significatives entre les différents relevés, soit une augmentation quasi constante du nombre de ces bactéries. Au fur et à mesure que la journée s'écoule, ces valeurs vont de 4,73 à 5,74 pour les bactéries totales à 35°C et de 5,08 à 5,83 pour les bactéries totales à 22°C.

On remarque cependant une légère diminution après 14h30 pour tous les groupes microbiens, à l'exception des coliformes fécaux. Cette diminution pourrait s'expliquer par le fait que durant la période de repos de l'après-midi, un rinçage sommaire de l'équipement est effectué.

Pour les coliformes totaux, on a observé une très forte augmentation entre le début des opérations et le second prélèvement, ce nombre passant de 1,55 à 3,13. Toutefois, ce nombre a décru par la suite pour demeurer presque constant jusqu'à la fin des opérations, soit 2,84.

Les coliformes fécaux n'ont pas subi cette même poussée après le début des opérations et leur accroissement a été régulier et faible pour atteindre le plus haut niveau à la fin des opérations: leur nombre est passé de 0,24 à 0,70.

En ce qui concerne les streptocoques fécaux, on a observé, tout comme dans le cas des coliformes totaux, une forte augmentation après le début des opérations. Le nombre de ces microorganismes est augmenté de plus de 36 fois (1,59 à 3,16), pour ensuite demeurer constant jusqu'à la fin de la journée. Toutefois, on a pu observer le même phénomène que dans le cas de bactéries totales, c'est-à-dire une légère diminution après le prélèvement de 14h30 (3,23 à 3,10), qui serait sans doute attribuable au rinçage de l'équipement.

Pour ce qui est des levures et moisissures, on a observé

la même tendance que pour les coliformes totaux, soit une forte augmentation après le début des opérations (3,62 à 4,58), puis leur nombre est demeuré constant jusqu'à la fin de la journée.

En comparant ces résultats avec d'autres obtenus antérieurement, à la même usine (Simard et Auclair, 1981), on a noté pour les prélèvements de 7h00, que le degré de contamination est sensiblement du même ordre pour les bactéries totales à 35°C (4,73 et 4,66) et à 22°C (5,67 et 5,26) de même que pour les streptocoques fécaux (1,59 et 1,44). Par contre, dans la présente étude, les coliformes totaux furent légèrement plus nombreux, tandis que les dénombrements des levures et des moisissures furent plus élevés par un facteur de 6. Aucune comparaison n'a pu être faite à l'endroit des coliformes fécaux, ce type de bactérie n'ayant pas été dénombré dans le travail précédent (Simard et Auclair, 1981).

Contamination en fonction de la saison

La variation saisonnière (moyenne±écart-type) de chaque type de microorganisme en fonction de onze endroits à cinq périodes différentes de prélèvement d'une même journée, est présentée au tableau 2, pour chacun des dix relevés sanitaires. On remarque qu'il existe, pour tous les groupes de microorganismes, des différences significatives entre les différents relevés. Le nombre de bactéries totales à 35°C et 22°C a varié quelque peu au cours de l'année. Cette augmentation fut néanmoins importante entre mai et septembre (4,99 à 5,91 pour les bactéries totales à 35°C et 4,88 à 6,04 pour les bactéries totales à 22°C) suivi d'une diminution entre septembre et janvier pour les bactéries totales à 35°C (5,91 à 4,85) et

Tableau 1. Niveau de contamination microbienne dans un abattoir de volaille en fonction du temps d'opération.^{1,2}

Heures de prélèvement	Bactéries totales à 35°C	Bactéries totales à 22°C	Coliformes totaux	Coliformes fécaux	Streptocoques fécaux	Levures et moisissures
7h00 ³	4,73 ± 0,15a	5,08 ± 0,13a	1,55 ± 0,18a	0,24 ± 0,07a	1,59 ± 0,17a	3,62 ± 0,17a
10h00	5,41 ± 0,11b	5,64 ± 0,10b	3,13 ± 0,14c	0,34 ± 0,07a	3,13 ± 0,12b	4,58 ± 0,12c
12h00	5,58 ± 0,13b	5,58 ± 0,11b	2,83 ± 0,15b	0,59 ± 0,09b	3,16 ± 0,11b	4,32 ± 0,13b
14h30	5,74 ± 0,12c	5,83 ± 0,11c	3,12 ± 0,14b	0,60 ± 0,09b	3,23 ± 0,13c	4,54 ± 0,12b
16h30	5,62 ± 0,13b	5,67 ± 0,13b	2,84 ± 0,15b	0,70 ± 0,09c	3,10 ± 0,14b	4,34 ± 0,15b

¹Les valeurs indiquent les moyennes et leur écart-type (log 10).
²Les moyennes ayant la même lettre dans une même colonne ne sont pas significativement différentes (P<0,05).
³Le nombre d'échantillons par h de prélèvement est de 110.

Tableau 2. Niveau de contamination microbienne dans un abattoir de volaille en fonction de la saison.^{1,2}

Date de prélèvement	Bactéries totales à 35°C	Bactéries totales à 22°C	Coliformes totaux	Coliformes fécaux	Streptocoques fécaux	Levures et moisissures
77-05-24 ³	4,99 ± 0,16a,b	4,88 ± 0,17a	2,65 ± 0,25a,b	0,02 ± 0,02a	2,46 ± 0,23a,b	3,88 ± 0,17a,b
77-07-12	5,31 ± 0,20b,c,d,e	4,91 ± 0,20a	2,31 ± 0,27a	0,55 ± 0,14b	2,73 ± 0,19a,b,c	3,79 ± 0,23a
77-08-09	5,71 ± 0,18e,f	5,90 ± 0,15c,d	2,83 ± 0,24a,b	0,43 ± 0,10b	3,08 ± 0,19b,c	4,33 ± 0,22a,b,c
77-09-06	5,91 ± 0,16g	6,04 ± 0,15g	3,11 ± 0,21c	0,59 ± 0,11b	3,24 ± 0,17d	4,43 ± 0,20a,b,c
77-10-12	5,76 ± 0,16f	5,88 ± 0,16c,d	2,70 ± 0,23a,b	0,67 ± 0,12c	3,16 ± 0,19c	4,31 ± 0,20a,b,c
77-11-08	5,68 ± 0,15d,e,f	5,96 ± 0,14d	2,85 ± 0,21b	0,58 ± 0,11b	3,09 ± 0,19c	4,49 ± 0,18c
77-12-06	5,47 ± 0,15c,d,e,f	5,78 ± 0,14c,d	2,90 ± 0,21b	0,52 ± 0,11b	2,95 ± 0,18b,c	4,40 ± 0,18a,b,c
78-01-12	4,85 ± 0,18a	5,47 ± 0,16b,c	2,76 ± 0,21a,b	0,42 ± 0,12b	2,20 ± 0,23a	4,15 ± 0,24a,b,c
78-02-09	5,12 ± 0,23a,b,c	5,21 ± 0,18a,b	2,31 ± 0,20a,b	1,13 ± 0,18b	2,77 ± 0,22b,c	4,44 ± 0,19b,c
78-03-08	5,15 ± 0,21a,b,c,d	5,57 ± 0,17b,c,d	2,52 ± 0,24a,b	0,04 ± 0,04a	2,73 ± 0,25a,b,c	4,57 ± 0,17d

¹Les valeurs indiquent les moyennes et leur écart-type (log 10).
²Les moyennes ayant la même lettre dans une même colonne ne sont pas significativement différentes (P<0,05).
³Le nombre d'échantillons par date de prélèvement est de 55.

entre septembre et février pour les bactéries totales à 22°C (6,04 à 5,20) correspondant à une période plus froide de l'année. Le nombre de coliformes totaux évolue différemment et varie d'un relevé à l'autre sans tendance générale spécifique et les différences ne sont pas toujours significatives. La représentation graphique de ces variations est présentée à la figure 2.

Par contre, les coliformes fécaux semblent suivre le même cheminement que les bactéries totales et leur nombre augmente graduellement de mai à octobre (0,03 à 0,67) pour décroître par la suite jusqu'en janvier (0,42). En faisant abstraction du taux élevé observé en février (1,13), cette diminution serait constante jusqu'en mars (0,04). La représentation graphique de ces variations est présentée à la figure 3.

Les streptocoques fécaux de même que les levures et moisissures calquent sensiblement la même tendance que les bactéries totales. Dans le cas des streptocoques fécaux, l'augmentation est graduelle de mai à septembre (2,46 à 3,24) suivie d'une diminution de septembre à mai (3,24 à 2,46) telle que présentée à la figure 4. Dans le cas des levures et moisissures (figure 5), nous observons aussi une augmentation de mai à septembre (3,88 à 4,43) suivie d'une nouvelle augmentation entre janvier et mars (4,16 à 4,57).

Le phénomène observé par Miskimin et coll. (1976) à propos de la relation existant entre la proportionnalité des différents types de microorganismes, se retrouve également dans ce cas-ci, tel que présenté aux figures 2, 3, 4 et 5.

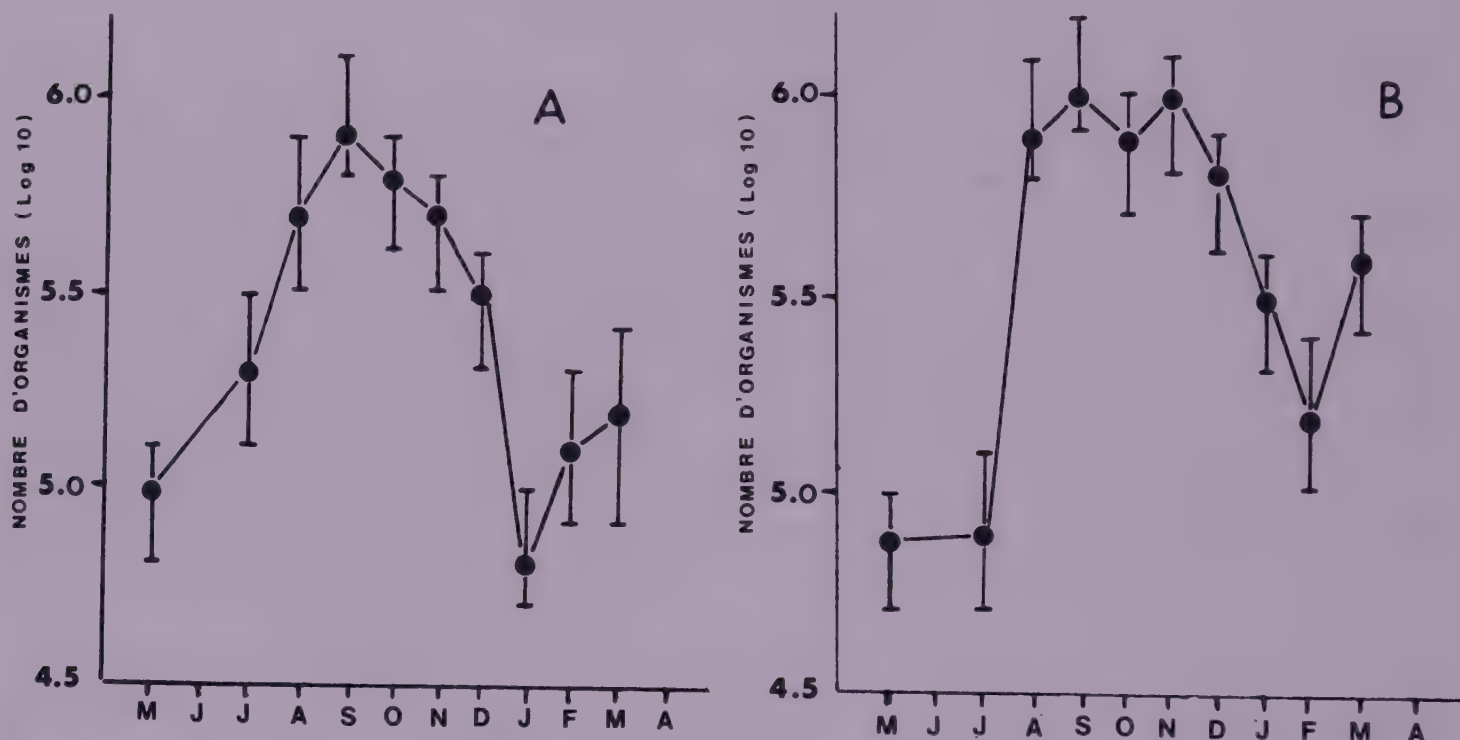


Fig. 2. Variation du nombre de bactéries totales (moyenne et écart-type) à 35°C (A) et 22°C (B) en fonction des dates de prélèvements.

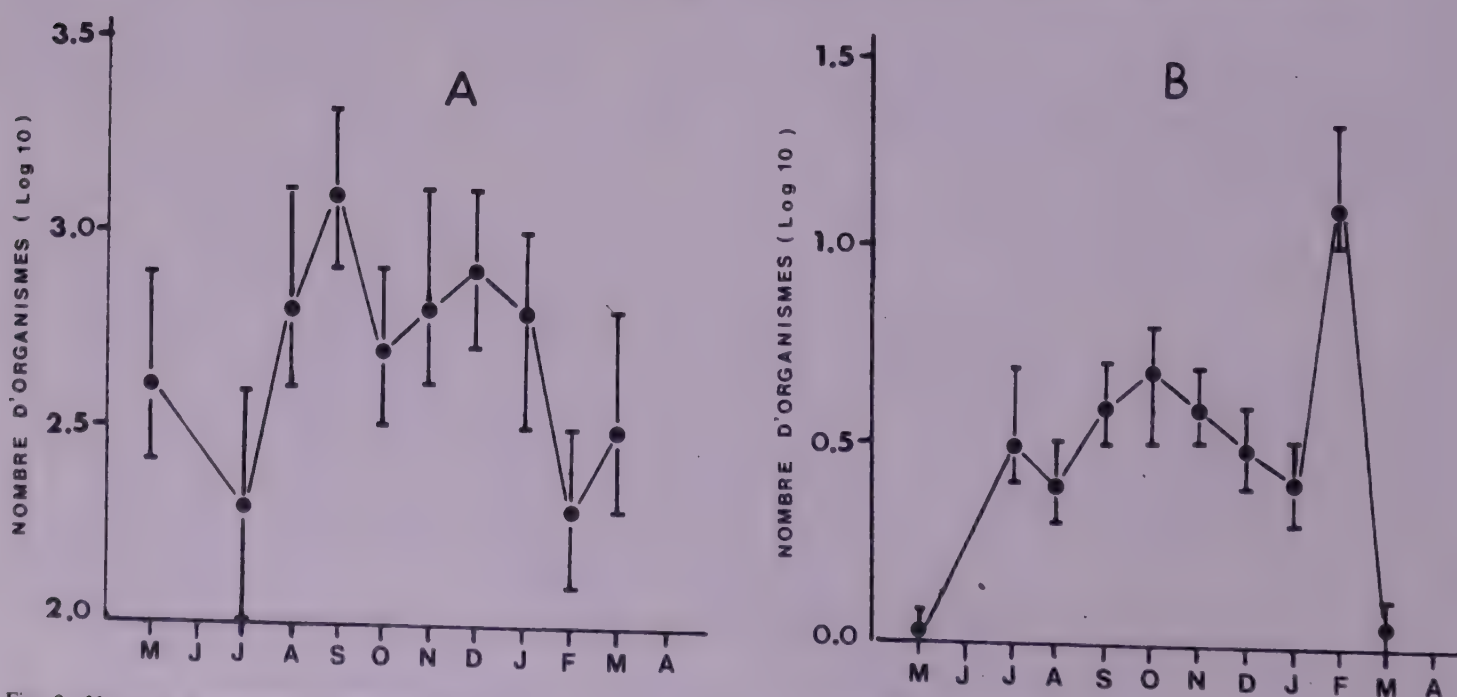


Fig. 3. Variation du nombre de coliformes totaux (A) et fécaux (B) (moyenne et écart-type) en fonction des dates de prélèvement.

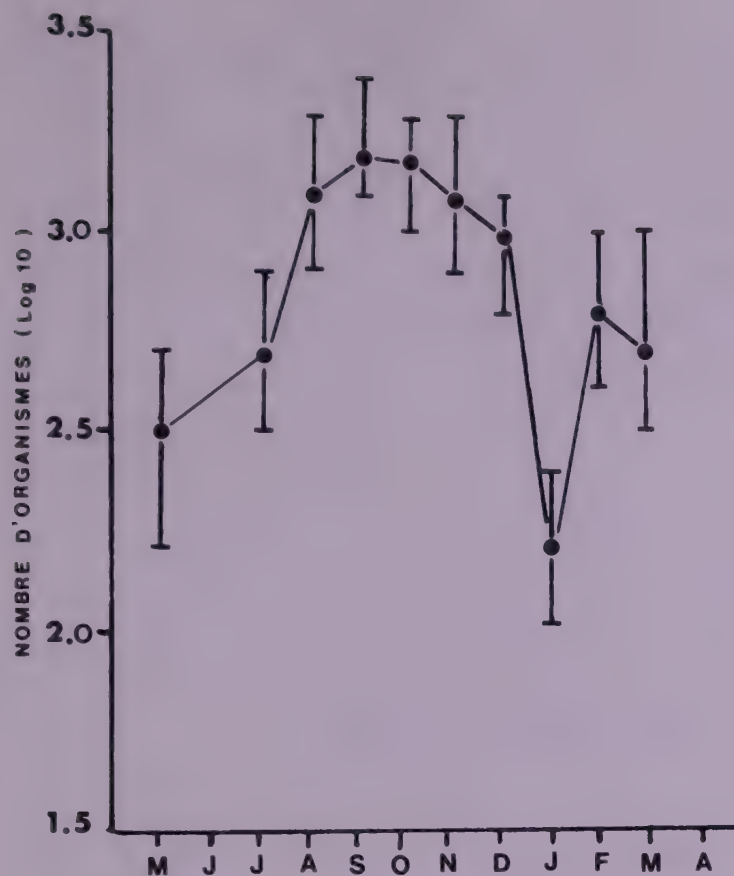


Fig. 4. Variation du nombre de streptocoques fécaux (moyenne et écart-type) en fonction des dates de prélèvement.

Endroit de contamination sur la chaîne de production

Les moyennes de chaque groupe de microorganismes indépendamment des cinq prélèvements horaires effectués lors des dix relevés sanitaires sont présentés au tableau 3. Il existe de fortes différences (significatives) entre les endroits échantillonnés (voir figure 1).

En considérant chaque groupe de microorganisme, on s'aperçoit que le maximum ne se retrouve pas toujours au même point d'échantillonnage. Les cages à poulets font cependant exception, bien qu'elles soient fabriquées de matière plastique et perforées à intervalles réguliers, favorisant ainsi un lavage efficace. Cependant, elles sont lavées à l'aide d'une laveuse automatique où les jets d'eau ne sont pas assez puissants et la durée de lavage trop courte. Il en résulte donc un accroissement de la contamination après usages répétés.

Pour les bactéries totales à 35 et 22°C sur les carcasses de poulets de même que sur les dallots d'emballage et la table de travail au "Cry-O-Vac," leur nombre (4,00) est inférieur à celui des autres endroits (5,00 et 6,00). Il existe toutefois une certaine différence pour l'eau de l'échaudeur où la température élevée favorise le développement des bactéries à 35°C (6,52) tandis qu'à 22°C le développement bactérien fut moins prononcé (5,06). On note aussi pour ces deux groupes de bactéries, que les eaux du prérefroidisseur et du refroidisseur constituent des milieux très contaminés (5,00 à 6,00/100 mL).

Le niveau de contamination sur le poulet après la douche, qui est de 1×10^5 bactéries totales à 22°C est comparable aux valeurs obtenues par Clark et Lentz (1969) sur des surfaces de poulets provenant de deux abattoirs différents. Par contre, dans un abattoir beaucoup

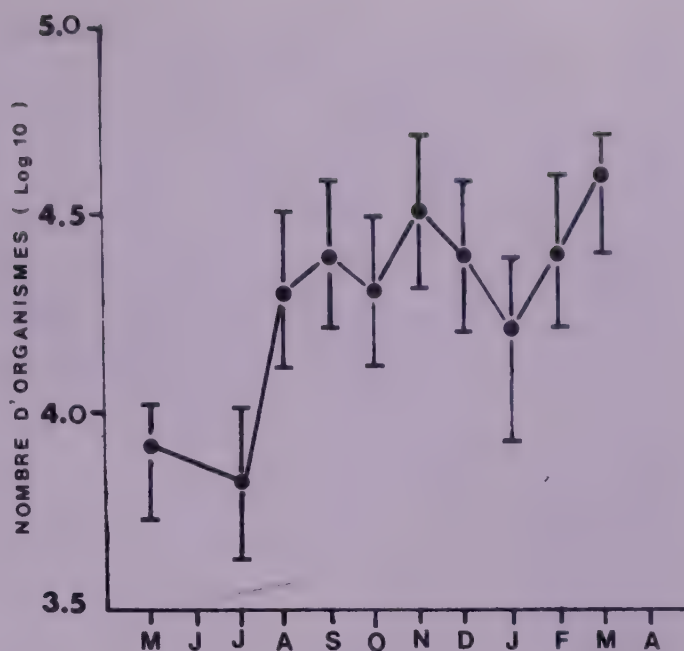


Fig. 5. Variation du nombre de levures et moisissures (moyenne et écart-type) en fonction des dates de prélèvement.

plus important que celui-ci étudié, Hamza et coll. (1978) ont obtenu des dénombrements de l'ordre de 1×10^6 sur des poulets dans le prérefroidisseur et le refroidisseur. Dans ce dernier cas, le débit des eaux du prérefroidisseur et du refroidisseur peut expliquer la différence des résultats.

On peut regrouper dans une autre catégorie les coliformes totaux ainsi que les coliformes et streptocoques fécaux. La majorité de ces bactéries sont de source fécale et c'est pourquoi on les retrouve en quantité assez importante après l'éviscération du poulet, de même que sur les poulets dans le prérefroidisseur et le refroidisseur (3,00). Les coliformes fécaux font cependant exception dans ces deux derniers cas. En effet, toutes les surfaces de poulets échantillonnées après l'étape d'éviscération sont fortement contaminées par ces bactéries. Il est important de constater que malgré la température élevée de l'eau d'échaudage, le nombre de streptocoques fécaux est très élevé (3,50) alors que celui des coliformes totaux et fécaux est demeuré à un niveau assez bas (1,16 et 0, respectivement).

En ce qui concerne les levures et les moisissures, l'eau d'échaudage, les dallots d'emballage et la table de travail du système "Cry-O-Vac" présentent le taux le plus bas (3,00). Leur nombre augmente (4,00) par la suite sur les surfaces de poulets, pour atteindre un taux comparable à celui des cages à poulets, ainsi que pour les eaux du prérefroidisseur et du refroidisseur.

Conclusion

Les résultats obtenus démontrent que la contamination des surfaces de travail de même que celle de quelques carcasses de poulet augmente graduellement au cours d'une journée de travail. Toutefois, cette contamination peut être diminuée en effectuant fréquemment un rinçage à l'eau courante de ces surfaces au cours de la période de travail.

En ce qui concerne la variation saisonnière du niveau de contamination, elle est surtout influencée par la température moyenne des saisons (à l'exception du relevé sani-

Tableau 3. Niveau de contamination microbienne dans un abattoir de volaille en fonction des points de prélèvement.^{1,2}

Endroit de prélèvement	Bactéries totales à 35°C	Bactéries totales à 22°C	Coliformes totaux	Coliformes fécaux	Streptocoques fécaux	Levures et moisissures
Cages à poulets ³	6,72 ± 0,18g	6,78 ± 0,19e	3,89 ± 0,21f	1,09 ± 0,17e	4,20 ± 0,13e	5,57 ± 0,20f
Eau d'échaudage	6,52 ± 0,17f	5,06 ± 0,11a,b	1,16 ± 0,19a	0,00 ± 0,00a	3,50 ± 0,20d	3,37 ± 0,17a,b
Crochets 2e ligne	5,96 ± 0,16d,e	6,01 ± 0,17d	2,21 ± 0,21a,b,c	0,27 ± 0,06a,b,c	2,86 ± 0,19b,c	3,68 ± 0,15b,c
Poulet après éviscération	5,12 ± 0,13c	5,07 ± 0,10a,b	3,59 ± 0,14c,d	0,59 ± 0,14c,d	3,60 ± 0,09d	4,62 ± 0,10d,e
Eau du pré-refroidisseur	6,12 ± 0,24e,f	6,59 ± 0,22d	3,44 ± 0,28a,b	0,26 ± 0,13a,b	3,48 ± 0,25d	5,67 ± 0,20f
Eau du refroidisseur	5,35 ± 0,21d	5,89 ± 0,20c	3,39 ± 0,26e,f	0,33 ± 0,10a,b,c	3,36 ± 0,24c,d	4,97 ± 0,22e
Poulet avant emballage	4,75 ± 0,13a,b	5,41 ± 0,09c	3,21 ± 0,08d,e	0,63 ± 0,12d	2,46 ± 0,15b	4,58 ± 0,10d,e
Dallot d'emballage	4,54 ± 0,14a	4,87 ± 0,11a	1,98 ± 0,19b	0,35 ± 0,10b,c	1,46 ± 0,20a	3,22 ± 0,14a,b
Poulet dans les bassins réfrigérés	4,73 ± 0,11a,b	5,15 ± 0,09a,b	2,77 ± 0,15c,d	0,86 ± 0,12d,e	2,68 ± 0,12b	4,30 ± 0,11d
Poulet coupé en neuf parties	4,71 ± 0,15a,b	5,22 ± 0,18b	2,86 ± 0,17d,e	1,06 ± 0,15e	2,35 ± 0,14b	4,14 ± 0,21c,d
Table de travail "Cry-O-Vac"	4,83 ± 0,14b,c	5,12 ± 0,17a,b	0,90 ± 0,24a	0,00 ± 0,00a	1,31 ± 0,20a	2,96 ± 0,22a

¹Les valeurs indiquent les moyennes et leur écart-type (log 10).

²Les moyennes ayant la même lettre dans une même colonne ne sont pas significativement différentes (P<0,05).

³Le nombre d'échantillon par endroit de prélèvement est de 50.

taire de février ou les dénombrements furent anormalement élevés). De plus, ce sont les cages à poulets qui ont le plus haut niveau de contamination. A cet égard, une modification du système de lavage s'impose. Les endroits utilisant de l'eau tels l'échaudeur, le prérefroidisseur et le refroidisseur, nécessiteraient une amélioration, notamment quant à la fréquence des changements d'eau.

On observe également une sélectivité dans le niveau de contamination des divers endroits échantillonnés. Ce niveau est sans doute influencé par la température et le degré d'humidité de l'environnement de même que par la nature du substrat disponible et la proximité de sources de contamination. Les informations obtenues permettront l'établissement d'un programme d'hygiène adéquat en choisissant un germicide efficace pour chaque groupe de contaminant microbien.

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Références

APHA. 1971. Standard Methods of Examination of Water and Wastewater. American Public Health Association, 1740 Broadway, New York, NY.

Clark, D.S. 1965. Method of estimating the bacterial population surface. Can. J. Microbiol. 11:407.

Clark, D.S. et Lentz, C.D. 1969. Microbiological studies in poultry processing plant in Canada. Can. Inst. Food Sci. Technol. J. 2:33.

Green, S. 1974. Microbiology in the poultry processing industry. Process Biochem. 9:27.

Hamza, A., Saad, S. et Witherow, J. 1978. Potential for water reuse in an Egyptian poultry processing plant. J. Food Sci. 43:1153.

Lillard, H.L. 1977. Microbiological characterization of water for recycling in poultry processing plants. J. Food Sci. 42:168.

Miskimin, D.K., Berkowitz, K.A., Solbert, M., Riha, W.E., Jr., Franke, W.C., Buchanan, R.L. et O'Leary, V. 1976. Relationships between indication organisms and specific pathogens in potentially hazardous food. J. Food Sci. 41:1001.

Simard, R.E. et Auclair, G. 1981. Niveau de contamination microbologique de quelques établissements d'abattage et de charcuterie "Approuvé Canada." Can. Inst. Food Sci. Technol. J. 14:128.

Snedecor, G.W. et Cochran, W.G. 1978. Statistical Methods. 6th ed. The Iowa State University Press, Ames, IA.

Van Schothorst, M., Northold, M.D. et Kampelmacher, E.H. 1976. Studies on the estimation of the hygienic condition of frozen broiler chickens. J. Hyg. 76:57.

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Effect of Composition on the Thermal Properties of Meat Emulsions¹

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Abstract

Thermal conductivities and thermal diffusivities of meat emulsions were measured to determine the influence of composition on the thermal properties. Moisture content of meat emulsions has a major influence on both the thermal diffusivity and thermal conductivity of meat emulsions. Composition of the emulsion has a strong bearing on the thermal properties, although the effect of moisture content seems to be consistent between compositions. Vegetable oil substitution for pork fat increased the diffusivity as did the addition of a binder. The addition of tripe, as a protein filler, introduced considerable variability in the thermal properties and special attention should be paid to formulations with this filler. Cooking of the meat emulsions resulted in a small decrease in thermal diffusivity, probably due to moisture loss during processing.

Résumé

Les conductivités et les diffusivités thermiques furent mesurées sur des émulsions carnées pour déterminer l'influence de la composition sur les propriétés thermiques. La teneur en humidité des émulsions carnées eut une influence importante sur la diffusivité et la conductivité thermiques des émulsions carnées. La composition de l'émulsion influence aussi fortement les propriétés thermiques, quoique l'influence du niveau d'humidité est apparue constante d'une composition à l'autre. La diffusivité fut augmentée par la substitution d'huiles végétales au gras de porc aussi bien que par l'addition d'un agent liant. L'addition de tripes, comme agent de remplissage protéique, a introduit une variabilité considérable dans les propriétés thermiques, indiquant le besoin de porter une attention spéciale aux formulations à base de cet ingrédient. La cuisson des émulsions carnées a causé une légère dimi-

nution de la diffusivité thermique, probablement due à la perte d'humidité au cours du traitement.

Introduction

Food safety is of paramount importance to the processing industry. In the area of meat processing, consumer concerns about salt content and the use of sodium nitrite in meat products increase the emphasis on thermal processing of such products as a means of ensuring adequate safety. Changes to existing processing parameters will affect both product quality and level of microbial activity. The characteristics or thermal properties of the material which govern the rates of heat transfer within the product can be defined either in terms of thermal conductivity or thermal diffusivity.

These properties of the material are fundamental to the calculation of thermal processes for the processing of food products and are related by:

$$\alpha = \frac{k}{\rho C} \quad (1)$$

where: α = thermal diffusivity
 k = thermal conductivity
 ρ = density
 C = specific heat

Changes in product formulations are frequently made in response to either ingredient availability or cost, and the effect of these changes on the quality and thermal properties should be well understood. The latter is particularly important if the processor is relying on heat treatment to achieve commercial sterility.

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Values of thermal conductivity for various meats, sausages and fats have been published by previous workers. Lentz (1961) reported the conductivities of several meats and gelatin gels over a 5°C-25°C range. Thermal conductivity values of 0.384 Wm⁻¹.°C⁻¹ and 0.427 Wm⁻¹.°C⁻¹ were listed for two different sausage formulations (Qashou *et al.*, 1972). For nine sausage formulations with fat contents ranging from 14-41%, and for moistures of 45-64%, the Meat Research Institute (1972) listed thermal diffusivity values ranging from 0.0697-0.0972 cm²/min.

Lentz (1961) and Sweat *et al.* (1973), reporting independently on the change in thermal conductivity of chicken meat with temperature, noted the abrupt change in conductivity at 0°C, with an attendant increase in value both above and below the freezing point.

Thermal diffusivities of model meat analog systems were determined by Rizvi *et al.* (1980). The thermal diffusivities of these analogs varied directly with water content and were in the same range as reported for sausages.

Sörenfors (1974) reported that the conductivity of uncoagulated meat increased both with moisture content and temperature, but that the conductivity of coagulated material did not change with temperature.

Materials and Methods

As part of an ongoing program in meat products research, thermal diffusivities and thermal conductivities of meat emulsions were determined. The influence of fat level and type, binder, protein filler and added moisture on the thermal properties of a basic meat emulsion were investigated.

Seven emulsion formulations were prepared by adding or replacing ingredients in a basic mixture of 60% boneless beef, 20% pork trim and 20% pork fat. Each formulation was tested at several different moisture contents, adjusted by adding moisture (as ice) during comminution.

Ingredients used in preparing the meat emulsions were obtained from standard commercial outlets. Pork trim and boneless beef were ground separately in a commercial meat chopper fitted with a 0.95 cm plate. The chopped ingredients were packaged and stored at -30°C until used. Other ingredients used included rindless pork fat, pure soybean oil, frozen beef tripe, meat binder, salt and water. Soybean oil was used to replace pork fat, while the other ingredients were added to the basic mixture in amounts expressed as a percentage of the base weight. Meat binder was added at the 7.5% level, while tripe was added at 10, 15 and 20% levels. Water (as ice) was added at 20, 27.5, 30, 42.5 and 50% levels to each of the seven emulsion formulae. Salt was added to all emulsions at the 2% level.

The emulsions were prepared with a commercial food cutter by adding partially thawed ingredients, ice and salt, and comminuting until an emulsion temperature of 3.5°C was achieved. Fat was then added and comminution continued to a final emulsion temperature of 14.5°C. The finished emulsions were stuffed into casings and thermal diffusivity cells prior to testing. Duplicate samples were tested with a Cenco moisture balance to determine the final moisture content of each emulsion.

Thermal conductivity was determined before and after cooking on three additional emulsions which were prepared using buckwheat shorts, Promine D and a Na Isolate as protein replacers. The raw emulsions were formulated to contain 65% moisture, and moisture following cooking was measured using the Cenco moisture balance.

Thermal diffusivity data was developed using a pseudo-steady state method (Dickerson, 1965) where a cylindrical sample is heated at a linear rate. Diffusivity is determined from the temperature lag between the centre of the sample and the outer surface.

Sample cells used in this work were constructed with thin stainless steel walls and measured 2.38 cm radius by 30 cm length. A foil thermocouple bonded to the inside wall of the cell measured the sample surface temperature, and a 0.3175 cm diameter stainless sheathed thermocouple probe positioned in the centre of the cell provided centre temperatures. Samples were heated at a rate of 0.625°C/min in a water bath and tests were terminated at a centre temperature of 75°C. The temperature ramp was generated using a Data Trak drum programmer to vary the set point on a Research Incorporated Micro-Thermac power controller with a maximum output of 7,200 W. This controller utilizes a zero firing SCR circuit and was used to power two 1,500 W immersion heaters in the water bath. Temperatures of the water bath, sample surface and centre were recorded using a Kaye 8000 data logger with 0.1°C resolution. Actual heating rates were determined for each test for use in the calculation of the thermal diffusivity.

The values reported for diffusivity represent a mean value over a temperature range of 15°-70°C.

Thermal conductivity data was obtained by using a transient line heat source method (Sweat, 1974). Derivations for the calculation of thermal conductivity by this method are detailed by Nix *et al.* (1967) and Gale (1965).

Probes were constructed from #23 hypodermic needles of 5 cm length (Figure 1). An insulated constantan wire inserted in the needles provided the heat source, while a copper constantan thermocouple, also inside the needle, was used to monitor the probe temperature (Figure 2). Heat densities of approximately 7 W/m during tests gave acceptable temperature rises during the 20 s testing time chosen. Sample temperatures of 2°C and 25°C were

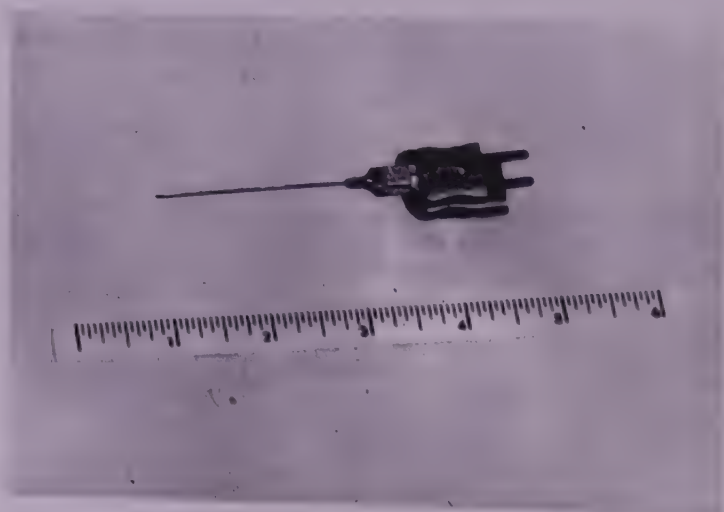


Fig. 1. Thermal conductivity probe (scale in inches).

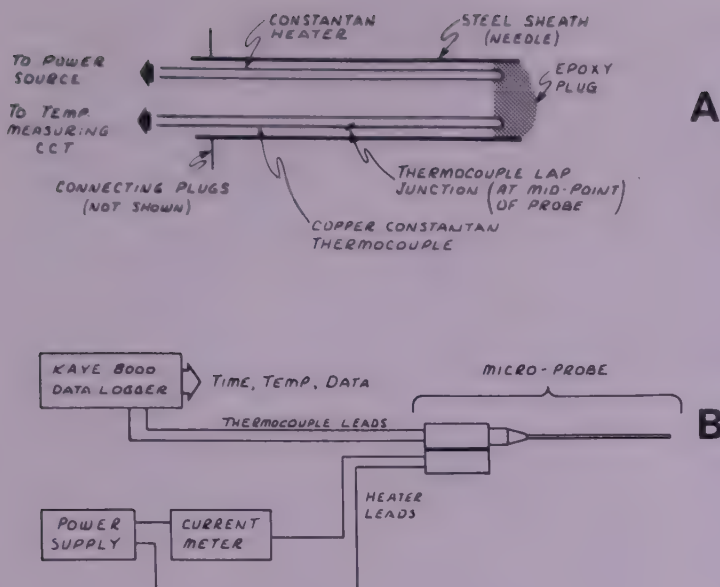


Fig. 2. (a) Detail of thermal conductivity probe.

(b) Schematic diagram of thermal conductivity probe instrumentation.

selected for test purposes. Power for the probe heater element was supplied by a Hewlett Packard DC power supply and monitored on a 4½ digit Fluke microammeter. Probe temperature was recorded on a 1 s interval with the Kaye 8000 data logger (Figure 2). Slope was calculated from twenty data pairs using a polynomial least squares curve fitting program. The probes were calibrated using 0.4% agar gel (Timbers and Robertson, 1976).

Results and Discussion

Thermal diffusivities of the seven meat emulsions are shown in Table 1. The basic meat emulsion had a diffusivity of 0.0701-0.0747 cm²/min depending on the moisture level of the product. All changes in formulation used in this study increased the thermal diffusivity relative to the base emulsion (Figure 3). The regression of thermal diffusivity with moisture was significant for all emulsions used except for the 10 and 20% tripe emulsions (Table 2). The increase was approximately 6% as the moisture content was increased from 56-66%. The source of fat affected thermal diffusivity, with the substitution of vegetable oil for part of the pork fat resulting in increased diffusivity values. This observation is consistent with that of Prandl *et al.* (1973) who observed higher heat transfer in vegetable fats than in animal fats. While increasing the level of substitution of vegetable oil for pork fat from 20-30% increased the thermal diffusivity, the slopes of the thermal diffusivity vs. moisture content lines for the two levels of oil substitution remained very similar. The addition of 7.5% binder (4% dextrose equivalent) increased the thermal diffusivity of the base emulsion. The effect of tripe addition was quite variable and was not consistent with the level of addition. The effect of tripe addition was also influenced by the moisture level, but again in an unpredictable manner. While the tripe used was all purchased from the same source, no specific quality tests were conducted on the material, and tripe variability may have been a source of variation.

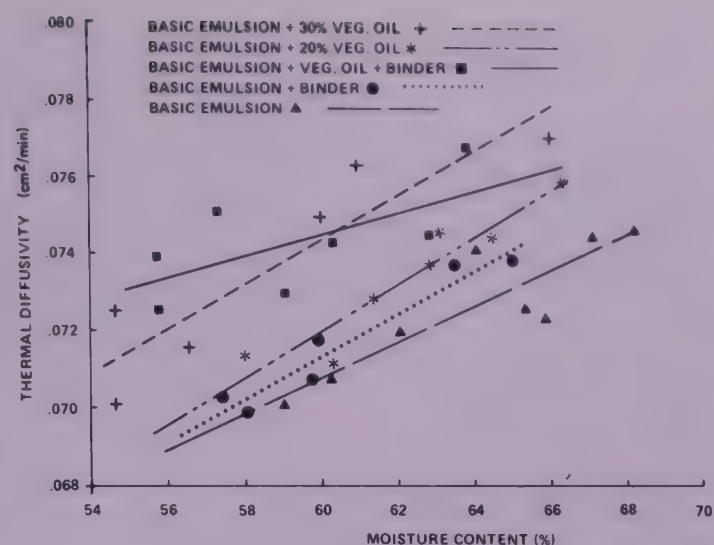


Fig. 3. Thermal diffusivity: effects of emulsion formulation over a range of moistures.

Statistical tests for differences in slope of α vs. moisture content among the different emulsions were not significant, but differences in location (intercept) were significant. Thermal diffusivity was influenced by the type of material as follows:

Vegetable oil (30%) > Vegetable oil (20%) > Pork fat
Binder > No binder

There is also a possible fat source by binder interaction, however this is probably small compared to the main effects.

Thermal conductivity increased with the moisture content of the meat emulsion as did the thermal diffusivity. The conductivity was also somewhat affected by temperature for the two temperatures used in testing. A T-test for paired observations showed that the thermal conductivity at 25°C was significantly higher ($P = 0.01$) than that at 2°C. Sweat *et al.* (1973) showed a similar slight rise in conductivity of chicken meat over this temperature range. Cooking of the raw emulsion resulted in a small but significant ($P = 0.01$) decrease in the thermal conductivity (Table 3). This difference can in all probability be explained by the loss of water during cooking. Some influence of setting up of the meat emulsion during cooking could be expected, however the effect is probably small compared to the influence of moisture loss. For the three cooked emulsions, the conductivity was consistently higher at 25°C than at 3°C.

Two areas requiring further investigation are indicated. Research is needed to determine the effects of varying protein and fat levels, and of replacing animal proteins with plant proteins. Preliminary data obtained with three protein replacers did not show any significant differences in conductivity between emulsions (Table 3) when substituted at the same level, however different replacers as well as different levels of replacement need to be studied.

The demonstrated effects of formulation changes on thermal processing parameters suggest caution be exercised in incorporating major changes to the formulation of meat emulsion products.

The formulation changes used in this study all resulted in increased thermal conductivities and thermal diffusivities,

Table 1. Effect of composition on the thermal diffusivity and thermal conductivity of meat emulsions.

Emulsion	Final moisture (% wet base)	Diffusivity 15°C-75°C (cm ² /min)	Conductivity ¹ 2°C (W/m °C)	Conductivity ¹ 25°C (W/m °C)
Base composition	59.1	0.0701	— ²	—
60% beef	60.3	0.0708	—	—
20% pork	62.1	0.0720	—	—
20% pork fat	64.1	0.0742	0.4162	0.4189
	65.4	0.0726	—	—
	65.9	0.0723	0.4119	0.4332
	67.2	0.0745	—	—
	68.3	0.0747	—	—
Base + 7.5% binder	57.5	0.0702	—	—
	58.1	0.0699	0.3786	0.3975
	59.8	0.0708	0.3911	0.4103
	60.0	0.0718	—	—
	63.6	0.0737	0.4056	0.4051
	65.1	0.0739	—	—
20% Vegetable oil replacing 20% pork fat	58.1	0.0713	—	—
	60.3	0.0712	0.3830	0.3812
	61.4	0.0729	0.3910	0.3993
	62.9	0.0737	—	—
	63.2	0.0746	—	—
	64.5	0.0744	0.4248	0.4194
	66.4	0.0759	—	—
30% Vegetable oil replacement	54.5	0.0701	0.3741	0.3553
	54.6	0.0727	—	—
	56.5	0.0716	0.3782	0.3755
	60.0	0.0750	0.4019	0.4088
	61.1	0.0763	—	—
	66.0	0.0770	—	—
20% Vegetable oil replacer + 7.5% binder	55.8	0.0739	—	—
	55.8	0.0726	0.3916	0.3789
	57.4	0.0751	—	—
	59.1	0.0730	0.3533	0.3885
	60.3	0.0743	0.4089	0.4048
	62.9	0.0745	0.4076	0.3939
	63.9	0.0767	—	—
Base + 10% tripe	61.0	0.0707	—	—
	61.7	0.0713	0.4086	0.4286
	62.4	0.0756	0.3945	0.4190
	64.7	0.0741	0.4033	0.4328
	65.9	0.0747	—	—
	67.6	0.0732	0.4383	0.4676
	68.0	0.0755	—	—
Base + 15% tripe	62.7	0.0716	0.4190	—
	65.0	0.0749	0.3928	0.4305
	66.6	0.0730	0.4203	0.4230
	67.4	0.0768	0.4061	0.4343
	69.3	0.0759	0.4591	0.4229
	69.3	0.0765	0.4273	0.4559
	71.1	0.0788	0.4363	0.4518
Base + 20% tripe	61.9	0.0740	0.3999	0.4228
	62.0	0.0725	0.4012	0.4065
	64.0	0.0758	0.4001	0.4232
	64.4	0.0734	—	—
	65.9	0.0743	0.4239	0.4400
	66.8	0.0795	0.3971	0.4316
	67.2	0.0741	—	—
	70.3	0.0768	0.4525	0.4545
	70.8	0.0747	—	—

¹Each thermal conductivity value is the mean of four replicates.

²Conductivities were not determined for samples indicated with a dash.

and consequently any errors introduced by using the base emulsion conductivity in thermal process calculations would be conservative (i.e., changes in emulsion formu-

lation would result in some degree of overprocessing). For substitutions other than those studied, the effects on conductivity should be assessed.

Table 2. Regression equations for the effect of moisture with the different emulsion compositions.

Composition	Regression Equation ¹	r ²
Base emulsion	$\alpha = 0.0429 + 0.000463x$	0.779
Base + binder	$\alpha = 0.0381 + 0.000554x$	0.945
Base + vegetable oil (20%)	$\alpha = 0.0356 + 0.000606x$	0.903
Base + vegetable oil (30%)	$\alpha = 0.0402 + 0.000569x$	0.828
Base + vegetable oil + binder	$\alpha = 0.0574 + 0.000284x$	0.450
Base + 10% tripe	$\alpha = 0.0479 + 0.000397x$	0.336
Base + 15% tripe	$\alpha = 0.0259 + 0.000733x$	0.765
Base + 20% tripe	$\alpha = 0.0455 + 0.000322x$	0.197

¹ α = Thermal diffusivity (cm²/min); x = Moisture content (%).

Table 3. Influence of cooking on the thermal conductivity of three meat emulsions formulated with protein replacers.

Emulsion ^{1,2}	Conductivity (W/m °C)			
	Temperature (°C) ³	Raw ⁴	Temperature (°C)	Cooked
1 Emulsion with Promine D protein replacer	-2	.4293 ⁵	2.0	.3964
	23	.4199	25.0	.4045
2 Emulsion with Na isolate protein replacer	0	.4416	3.5	.3812
	23	.4363	25.0	.4081
3 Emulsion with buckwheat shorts protein replacer	-2	.4053	3.5	.3736
	22	.4256	25.0	.3915

¹Emulsion formulation: beef 22.2%, pork trim 14.8%, protein replacer 24.7%, salt 1.0%, pork fat 14.8%, ice 21.4%, spices 1.1%.

²All emulsions were formulated for an initial moisture content of 65%. Final moisture content of the cooked emulsions were: 1, 56%; 2, 57.1%; and 3, 59.1%.

³For a paired comparison of means the difference between temperatures was significant at P = 0.01.

⁴For a paired comparison of means the difference between raw and cooked emulsions was significant at P = 0.01.

⁵All values given are the means of duplicate samples except raw emulsion 3.

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References

- Dickerson, R.W. 1965. An apparatus for the measurement of thermal diffusivity of foods. *Food Technol.* 19:880.
- Gale, E.H. 1965. Quick determination of thermal conductivity of potting compounds by a transient technique. *IEE Trans. Instrum. Measurement*:46.
- Lentz, C.P. 1961. Thermal conductivity of meats, fats, gelatin gels and ice. *Food Technol.* 15:243.
- Meat Research Institute. 1972. Thermal properties of meat. Special Report #1. Meat Research Institute, Langford, Bristol, England.
- Nix, G.H., Lowery, G.W., Vachon, R.S. and Tanger, G.E. 1967. Direct determination of thermal diffusivity and conductivity with a refined line-source technique. In: *Thermophysics of Spacecraft and Planetary Bodies*. Academic Press Inc., New York, NY.
- Prandl, O., Polke, E. and Matky, R. 1973. Effect of type of fat and emulsifier on heat transfer in emulsions. *Fleischwirtschaft* 53(9):1251.
- Qashou, M.S., Vachon, R. and Touloukian, Y.S. 1972. Thermal conductivity of foods. Research Report No. 2224-RP-62. Pres. ASHRAE, New Orleans, LA. January 23-27.
- Rizvi, S.S.H., Blaisdell, J.L. and Harper, W.J. 1980. Thermal diffusivity of meat analog systems. *J. Food Sci.* 45:1727.
- Sörenfors, P. 1974. Determination of the thermal conductivity of minced meat. *Lebensm.-Wiss. Technol.* 7(4):236.
- Sweat, V.E., Haugh, C.G. and Stadelman, W.J. 1973. Thermal conductivity of chicken meat at temperatures between -75 and 20°C. *J. Food Sci.* 38:158.
- Sweat, V.E. 1974. Experimental values of thermal conductivity of selected fruits and vegetables. *J. Food Sci.* 39:1080.
- Timbers, G.E. and Robertson, G.D. 1976. An inexpensive thermal conductivity probe for in-situ measurements. Report No. 7404-614 from Engineering Research Service, Agriculture Canada, Ottawa, ON.

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Positional Isomers of *trans*-Octadecenoic Acids in Margarines

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Abstract

The positional distribution of the double bond in *trans*-octadecenoic acids was determined in various margarines available in 1978 and 1980. The total amount of *trans* fatty acids did not vary appreciably in the 2 years sampled. As expected, the isomers ranged from $\Delta 5$ to $\Delta 15$ with the major ones being $\Delta 9$, $\Delta 10$ and $\Delta 11$. Variations, however, were encountered in this pattern. Margarines made in 1978 from a nonspecified vegetable oil had more $\Delta 9$ and less $\Delta 10$ and $\Delta 11$ than those from soybean oil or corn oil. In 1980, vegetable oil margarines obtained locally resembled soybean oil margarines. In soybean oil and vegetable oil margarines of the same brand, more $\Delta 8$ and $\Delta 9$ were present in tub than in print types, whereas the latter contained more of the $\Delta 10$ to $\Delta 15$. Different brands from the same oil showed significantly different patterns, probably reflecting differences in processing. The pattern of positional isomers in *trans*-octadecenoates from margarines is a result of differences in source of oil and conditions of processing.

Résumé

On a déterminé la distribution positionnelle de la double liaison dans les acides *trans*-octadécénoïques tels qu'isolés de diverses margarines disponibles sur le marché en 1978 et 1980. Le niveau total des acides gras *trans* n'a pas varié de façon appréciable entre ces deux périodes d'échantillonnage. Les isomères comprenaient la gamme prévue de $\Delta 5$ à $\Delta 15$, les plus importants étant le $\Delta 9$, le $\Delta 10$ et le $\Delta 11$. On a cependant rencontré des variations dans ce profil. Les margarines de 1978 à base d'huile(s) végétale(s) non-identifiée(s) contenaient plus de $\Delta 9$ et moins de $\Delta 10$ et de $\Delta 11$ que celles à base d'huile de soya ou d'huile de maïs. En 1980, les margarines à base d'huile(s) végétale(s) non-identifiée(s) obtenues localement ressemblaient aux margarines à base d'huile de soya. En comparant des marques identiques, les margarines à base d'huile de soya ou à base d'huile(s) végétale(s) non-identifiée(s) en pots contenaient plus de $\Delta 8$ et de $\Delta 9$ que celles en pains, lesquelles contenaient davantage des isomères $\Delta 10$ à $\Delta 15$. Des marques différentes mais avec la même désignation d'huile de base ont montré des variations significatives dans leur profil d'isomères. Ces variations reflètent probablement des différences dans le procédé de transformation. Le profil des isomères de position des acides *trans*-octadécénoïques dans les margarines est influencé par le type d'huile utilisé et les conditions qui prévalent au cours de la transformation.

Introduction

Recent dietary and biochemical work with positional

isomers of monoenoic fatty acids has emphasized the importance of the position as well as configuration of the double bond. Some positional isomers may be accumulated and others excluded from a lipid class or tissue (Reichwald-Hacker *et al.*, 1979; Wood, 1979). The *trans*-octadecenoates changed the activity of acyltransferases (Okuyama *et al.*, 1972) and inhibited desaturases (Mahfouz *et al.*, 1980) depending on the position of the double bond. Our main source of these isomers is partially hydrogenated fats and oils. Shortenings and margarines have been analyzed for positional isomers in the United States (Scholfield *et al.*, 1967; Carpenter and Slover, 1973). In view of a different oil supply in Canada, it appeared likely that the positional isomers of the hydrogenated fat would be different. This paper reports the distribution of the double bond in *trans*-octadecenoic acids from various margarines available in the Ottawa region in 1978 and 1980.

Materials and Methods

Margarines obtained locally were extracted with diethyl ether and the lipids transmethylated as previously described (Marchand and Beare-Rogers, 1982). The methyl esters were separated by silver nitrate-TLC, with chloroform as solvent, according to Wood and Snyder (1966). The band corresponding to *trans*-monoenes (mainly *trans*-octadecenoates) was visualized under ultraviolet (UV) after spraying with 2,7-dichlorofluorescein, scraped off, and the material transferred to a Pasteur pipette and eluted with diethyl ether.

The *trans*-monoenes extract was submitted to ozonolysis and, after cleavage by triphenylphosphine, the products were analyzed by gas chromatography (GC) according to Beroza and Bierl (1967). The gas chromatograph was a Hewlett Packard model 7602A equipped with a flame ionization detector and a Hewlett Packard model 3380A digital integrator. The column was 3.7 m x

Table 1. Percent *trans* fatty acids in various brands of margarines from different oils and packages in 1978 and 1980.

Oil	Package type	Year	Brands							Mean
			A	B	C	D	E	F	G	
Soybean	Tub	1978	13.7	13.1	24.0	16.2	— ¹	—	—	16.8
		1980	16.8	15.7	15.5	—	14.4	—	—	15.6
Soybean	Print	1978	30.7	—	—	—	—	—	—	30.7
		1980	30.5	31.2	34.0	—	—	—	—	31.9
Corn	Tub	1978	10.2	9.4	10.0	10.9	10.7	—	—	10.2
		1980	10.9	10.7	9.4	13.4	11.4	—	—	11.2
Corn	Print	1978	21.9	25.8	26.3	—	—	—	—	24.7
		1980	—	21.5	29.1	—	—	—	—	25.3
Vegetable	Tub	1978	24.1	27.4	26.1	12.6	19.3	—	—	21.9
		1980	18.2	—	20.0	16.5	20.4	16.7	14.6	17.7
Vegetable	Print	1978	30.0	27.1	32.9	—	—	—	—	30.0
		1980	29.9	32.2	36.4	31.6	39.3	—	—	33.9

¹Not available.

3.2 mm stainless steel packed with 5% Carbowax 20 M on 60/80 mesh Gas Chrom Q. It was operated isothermally at 50°C for 6 min and then programmed at 6°C/min to 200°C. The position of the double bond was ascertained by the aldehyde or aldehyde ester mole percentage or both using a correction factor as described by Van der Plank (1972).

Trans unsaturation was determined by the AOAC (1975) method.

Results

As can be seen in Table 1, the total amount of *trans* fatty acids varied in the respective groups according to the oil source and the type of margarine (tub or print). Those designated as corn oil (CO) margarines had a lower content of *trans* fatty acids than soybean oil (SO) or vegetable oil (VO) margarines of both the tub and print types. In all of the margarines analyzed, the print samples contained more *trans* fatty acids than did the tub samples of the same oil source, although some VO tub margarines had more *trans* fatty acids than some CO print samples.

The distribution of *trans*-octadecenoic positional isomers extended from $\Delta 5$ to $\Delta 15$. As can be seen in Figure 1, VO margarines from the 1978 samples showed more $\Delta 9$ and less $\Delta 10$ and $\Delta 11$ than SO or CO margarines. Since VO margarines could be made from any oil or mixture, it is imprecise to compare them with the other two that have a specified oil source. Nevertheless, since mixtures of Canola and soybean oils are used in many cases, it is possible to ascertain the main component by the level of palmitic acid. A low palmitic acid level (around 5%) indicates the predominant use of Canola oil in the mixture. This was the case in 1978 VO tub samples but not in the 1980 samples in which the level of palmitic acid and the isomeric profile tended to resemble those of SO margarines.

Tub and print type margarines of the same brands were compared in each oil group. In the SO group, only one brand was represented in both tub and print samples (Figure 2A) and may not have been representative of the group. However, an average of the 1980 brands in the tub and print type (Figure 2B) demonstrated the same general trend: more isomers in the $\Delta 10$ to $\Delta 15$ range in the print

samples. In the three CO brands that were represented in both tub and print types in 1978 and 1980 (Figure 3), the print samples had a higher content of positional isomers in the $\Delta 5$ to $\Delta 8$ range. However, the differences were rather small. For VO samples, different oil mixtures may be used for tub and print, even for the same brand. Thus, the differences between tub and print for these samples must be interpreted with caution. One brand that had a relatively similar fatty acid composition in both tub and print samples was compared (Figure 4). The tub sample showed a higher amount of the isomers in the $\Delta 6$ to $\Delta 9$ range, as in the SO group.

Some differences could be detected among different brands from the same oil source. In VO samples, this is explainable, again, in view of the possible different oil mixtures used. In CO samples, the differences were small and are not shown. In the 1978 SO samples, however, some interesting differences were observed (Figure 5). One of these samples (Brand C) differed markedly from the others in its profile of *trans* positional isomers. It had much more of the $\Delta 9$ *trans* isomer. On the

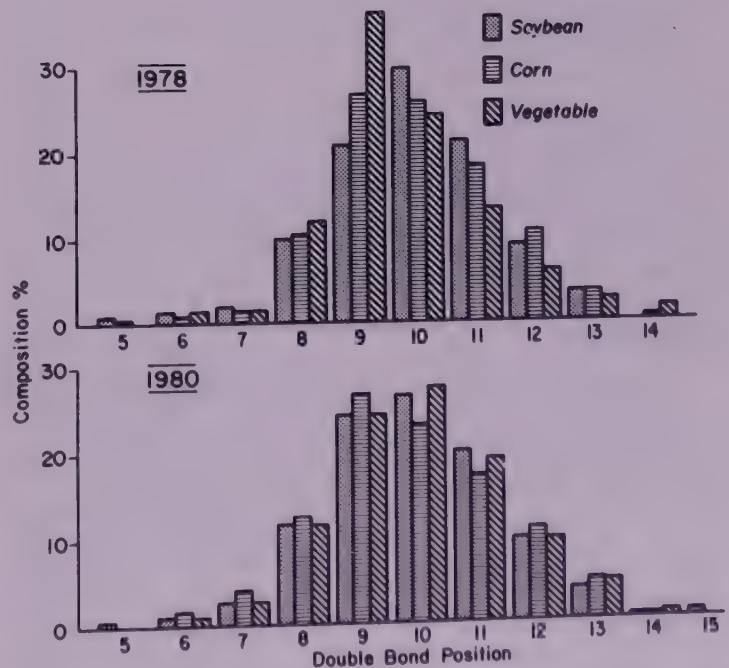


Fig. 1. Distribution of *trans*-18:1 positional isomers in tub margarines from differently designated oils.

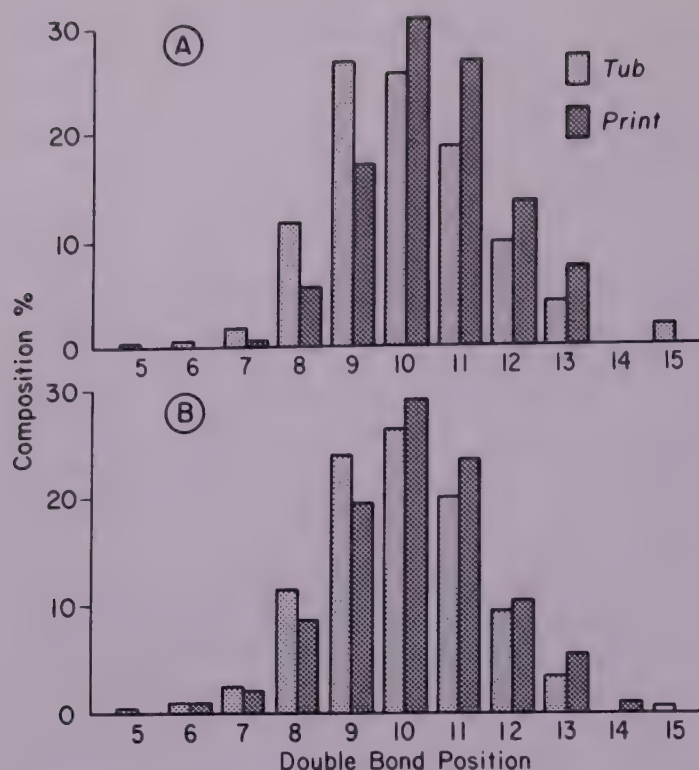


Fig. 2. Distribution of *trans*-18:1 positional isomers in 1980 tub and print margarines made from SO.

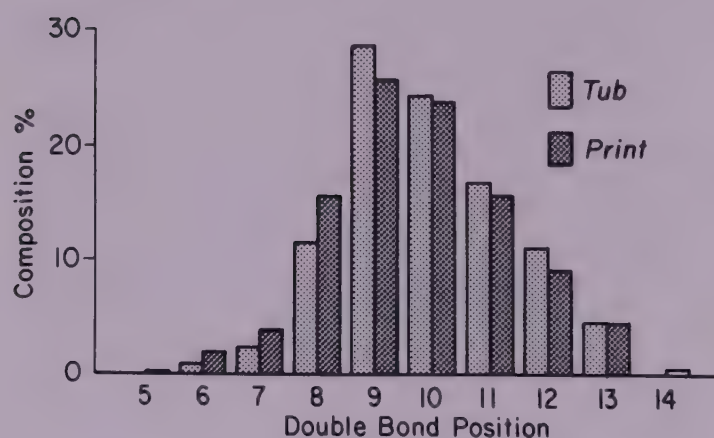


Fig. 3. Distribution of *trans*-18:1 positional isomers in tub and print margarines made from CO.

other hand, its level of palmitic acid was only 7.6%, which is somewhat low for a margarine supposedly made exclusively from SO. Moreover, although all these samples were of the tub type, they differed by their total amount of *trans* fatty acids.

Discussion

In general the SO samples had a similar positional isomer profile as reported for United States SO based margarines (Scholfield *et al.*, 1967; Carpenter and Slover, 1973). Our CO tub sample had a somewhat lower amount of $\Delta 11$ but the United States samples (Carpenter and Slover, 1973) contained about twice the amount of *trans* fatty acids, suggesting differences in processing. The really noteworthy difference came from the VO samples that had a higher proportion of $\Delta 9$ not previously observed in United States margarines. The pattern of migration of the double bond from the original position during

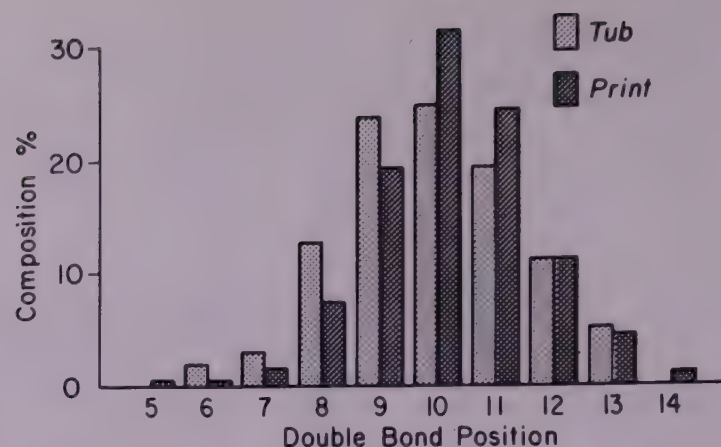


Fig. 4. Distribution of *trans*-18:1 positional isomers in 1980 tub and print margarines made from VO.

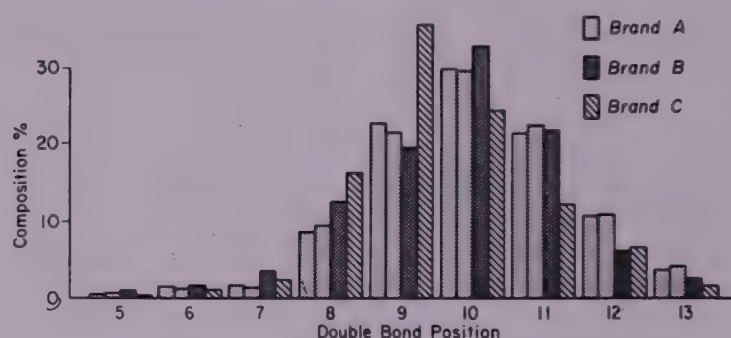


Fig. 5. Distribution of *trans*-18:1 positional isomers in three 1978 tub margarines made from SO. Brand A was analyzed in two packages of different sizes.

the hydrogenation process is related to the composition of the original oil. Linolenic acid would give mainly $\Delta 10$, $\Delta 11$, $\Delta 13$ and $\Delta 14$ *trans*-monoenes (Scholfield *et al.*, 1964), linoleic acid, mainly $\Delta 10$ and $\Delta 11$ (Scholfield *et al.*, 1967) and oleic acid, $\Delta 8$, $\Delta 9$ and $\Delta 10$ (Subbaram and Youngs, 1964). Thus, the higher amount of *trans* $\Delta 9$ isomer in some VO margarines where Canola oil may be used as the main component may be explained at least partly by the presence of up to 60% oleic acid in the original oil mixture. This higher amount of $\Delta 9$ isomer was also observed in one SO sample. Assuming that this sample was made from 100% soybean oil, apparently no other reason than the different conditions of hydrogenation that may have prevailed could account for this difference from the other SO samples. For example, parameters such as temperature, pressure and catalyst concentration do influence the selectivity of the hydrogenation (Teasdale, 1975; Puri, 1980). A less selective process is likely to give more $\Delta 9$ isomer because more oleic acid is isomerized.

It is apparent that some Canadian margarines made from an unspecified VO contain a high level of the $\Delta 9$ positional isomer in the *trans*-octadecenoates. In no case, however, did any isomer have a proportion greater than 40%. A mixture of positional isomers, as compared with a single isomer, may explain some divergent results in humans on the effect of *trans* fatty acids on blood cholesterol (Vergroesen, 1972; Mattson *et al.*, 1975). In one study (Mattson *et al.*, 1975), partially hydrogenated SO was used, and in the other (Vergroesen, 1972) a "hardened"

olive oil, as the source of *trans* fatty acids. The "hardened" olive oil was described as containing only the $\Delta 9$ isomer of the *trans*-18:1 (Vergroesen, 1972), whereas the partially hydrogenated SO probably contained many different positional isomers such as encountered in the margarines sold in the United States (Scholfield *et al.*, 1967; Carpenter and Slover, 1973) and in Canada (this study). Therefore, the dietary fats in the studies may not have been comparable.

As shown here, the isomers present in margarine vary depending on the VO used and the conditions of processing. The diversity of isomers must be kept in mind when appraising the nutritional implications of hydrogenated fat.

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References

- AOAC. 1975. Official Methods of Analysis, 12th ed. p. 497. Association of Official Analytical Chemists, Washington, DC.
- Beroza, M. and Bierl, B.A. 1967. Rapid determination of olefin position in organic compounds in microgram range by ozonolysis and gas chromatography. Alkylidene analysis. *Anal. Chem.* 39:1131.
- Carpenter, D.L. and Slover, H.T. 1973. Lipid compositions of selected margarines. *J. Am. Oil Chem. Soc.* 50:372.
- Mahfouz, M.M., Johnson, S. and Holman, R.T. 1980. The effect of isomeric *trans*-18:1 acids on the desaturation of palmitic, linoleic and eicosa-8,11,14-trienoic acids by rat liver microsomes. *Lipids* 15:100.
- Marchand, C.M. and Beare-Rogers, J.L. 1982. Complementary techniques for the identification of *trans*, *trans*-18:2 isomers in margarines. *Can. Inst. Food Sci. Technol. J.* 15:54.
- Mattson, F.H., Hollenbach, E.J. and Kligman, A.M. 1975. Effect of hydrogenated fat on the plasma cholesterol and triglyceride levels of man. *Am. J. Clin. Nutr.* 28:726.
- Okuyama, H., Lands, W.E.M., Gunstone, F.D. and Barve, J.A. 1972. Selective transfers of *trans*-ethylenic acids by acyl coenzyme A: Phospholipid acyltransferases. *Biochemistry* 11:4392.
- Puri, P.S. 1980. Hydrogenation of oils and fats. *J. Am. Oil Chem. Soc.* 57:850A.
- Reichwald-Hacker, I., Grosse-Oetringhaus, S., Kiewitt, I. and Mukherjee, K.D. 1979. Incorporation of positional isomers of *cis* and *trans*-octadecenoic acids into acyl moieties of rat tissue lipids. *Biochim. Biophys. Acta* 575:327.
- Scholfield, C.R., Butterfield, R.O., Davison, V.L. and Jones, E.P. 1964. Hydrogenation of linolenate X. Comparison of products formed with platinum and nickel catalysts. *J. Am. Oil Chem. Soc.* 41:615.
- Scholfield, C.R., Davison, V.L. and Dutton, H.J. 1967. Analysis for geometrical and positional isomers of fatty acids in partially hydrogenated fats. *J. Am. Oil Chem. Soc.* 44:648.
- Subbaram, M.R. and Youngs, C.G. 1964. Isomerization of monoethenoid acids during hydrogenation. *J. Am. Oil Chem. Soc.* 41:150.
- Teasdale, B.F. 1975. Processing of vegetable oils. In: *Oilseed and Pulse Crops in Western Canada*. pp. 551-585. Western Co-operative Fertilizers Ltd., Box 2500, Calgary, AB.
- Van der Plank, P. 1972. Evaluation of a gas chromatogram of a mixture containing aldehydes and aldehydic esters obtained by oxidative degradation of the positional isomers of methyl octadecenoate. *J. Am. Oil Chem. Soc.* 49:489.
- Vergroesen, A.J. 1972. Dietary fat and cardiovascular disease: Possible modes of action of linoleic acid. *Proc. Nutr. Soc.* 31:323.
- Wood, R. and Snyder, E. 1966. Modified silver ion thin-layer chromatography. *J. Am. Oil Chem. Soc.* 43:53.
- Wood, R. 1979. Incorporation of dietary *cis* and *trans* octadecenoate isomers in the lipid classes of various rat tissues. *Lipids* 14:975.

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Studies on Iraqi Truffles.

I. Proximate Analysis and Characterization of Lipids

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Abstract

Two varieties of Iraqi truffles (black, *Terfezia calveryi* and white, *Terfezia hafizi*) were examined for proximate and lipid composition. The tubers contained moisture, 74.3% and 80.0%, protein, 6.2% and 5.4%, and fat, 2.5% and 1.8%, respectively. The major fatty acids were palmitic, oleic and linoleic. The neutral lipid fraction contained linoleic 57-58% and palmitic 18-21%, as compared to 20% and 9-12% in the polar lipid fraction. Correspondingly oleic acid content was higher in polar lipids (25-34%) than in neutral lipids (11-14%). Branched chain fatty acids were identified mainly in the polar lipid fraction. β -sitosterol was the major sterol in the unsaponifiable fraction.

Résumé

Les compositions immédiate et lipidique furent déterminées sur deux variétés de truffes irakiennes (noires, *Terfezia calveryi* et blanche, *Terfezia hafizi*). Les tubercules étaient respectivement composés de 74,3% et 80,0% d'eau, 6,2% et 5,4% de protéine, et 2,5% et 1,8% de corps gras. Les principaux acides gras furent les acides palmitique, oléique et linoléique. La fraction lipidique neutre était composée de 57-58% d'acide linoléique et 18-21% d'acide palmitique par rapport à 20% et 9-12% dans la fraction lipidique polaire. Par contre, la teneur en acide oléique était plus élevée dans les lipides polaires (25-34%) que dans les lipides neutres (11-14%). Des acides gras à chaîne latérale furent identifiés principalement dans la fraction lipidique polaire. Le β -sitostérol fut le stérol principal dans la fraction non saponifiable.

Introduction

Two varieties of truffle tubers (black, *Terfezia calveryi*, and white, *Terfezia hafizi*) grow naturally in Iraq. Both varieties are harvested in large quantities which vary from season to season depending on the amount of rainfall. The tubers are globular in shape with a rough surface, and sometimes have crevices. They are marketed fresh and are used in a variety of well known Iraqi dishes.

The people of Iraq consume truffles in large quantities because of a belief that "truffle is the meat of the good soil" and they utilize the truffles not only as a delicacy but as a meat substitute.

Since the truffle tubers grow naturally in Iraq, they did not receive much attention from investigators. Al-Delaimy and Ali (1970) studied the spoilage of truffles upon storage, and reported the amino acid composition in both varieties (Al-Delaimy, 1977).

This paper reports the proximate analysis and lipid composition of the two varieties of truffle tubers growing naturally in Iraq.

Materials and Methods

Sample Preparation and Proximate Composition

Truffle tubers were purchased fresh from local markets, washed free of adhering soil, sliced and blended with water in a 1:1 ratio using a Waring blender. The mixture was immediately frozen in an alcohol cryoscopic bath, lyophilized and stored at -20°C for later use.

Samples of fresh tubers (in triplicate) were used for the determination of moisture by heating at 75°C in a vacuum oven (45-50 mm Hg) to a constant weight. Fat content was determined by a 16 h soxhlet extraction using petroleum ether (30-40 B.P.), and ash and total protein (N x 6.25) by AOAC (1970) methods. The carbohydrate content was established by difference.

Extraction and Fractionation of Total Lipids

About 2 g of the lyophilized truffle powder was extracted twice with 50 mL of 2:1 chloroform/methanol at 5°C using a magnetic stirrer for 1 h. The solvent system was decanted and the residue from the second extraction was filtered using Whatman #42 filter paper. The collected solvent system was dried over anhydrous sodium sulphate before it was evaporated to near dryness at 50°C using a rotary film evaporator under vacuum. The lipid residue was then dissolved in 20 mL of chloroform and transferred to the top of a silicic acid column prepared according to Borgström (1952). The neutral lipids fraction was eluted with 150 mL of chloroform and the polar lipids fraction with 150 mL of methanol.

Table 1. Proximate composition (%) of two varieties of Iraqi truffles on fresh and moisture-free basis.

Composition	Black		White	
	Fresh	Moisture-free	Fresh	Moisture-free
Moisture	74.32	-	80.01	-
Protein (N x 6.25)	6.26	24.38	5.45	27.26
Fat	2.57	10.02	1.82	9.11
Ash	0.91	3.55	1.08	5.40
Carbohydrates ¹	15.94	62.05	11.64	58.23

¹By difference.

Chromatographic Analysis

Fatty Acid Methyl Esters

The neutral lipids were interesterified according to the method of deMan (1964) and the polar lipids were esterified according to Morrison and Smith (1964). The fatty acid methyl esters were analyzed by gas liquid chromatography (GLC) on a Hewlett Packard model 5711A gas chromatograph equipped with dual flame ionization detector, differential electrometer, digital programmer and integrator/printer (Hewlett Packard model 3380A). The instrument was fitted with dual 180 cm x 0.3 cm ID stainless steel columns packed with 10% Silar 10 on 100-120 mesh chromosorb W A/W DMCS (Applied Science Laboratories, College Park, Penn.). Flow rates used were 25, 30 and 300 mL/min for nitrogen, hydrogen and air, respectively. Temperature programming was employed with an initial temperature of 150°C isothermally for 2 min, followed by programming to 200°C at a rate of 4°C/min and isothermally at 200°C for 16 min. Identification of fatty acid methyl esters was accomplished through the use of authentic standards of fatty acid methyl esters, supplied by Bast of Copenhagen, Denmark, Applied Science Laboratories, College Park, Penn. and Supelco Inc., Bellefonte, Penn.

Sterols

About 5 g of lyophilized truffle powder was refluxed for 3 h with 50 mL of 10% methanolic sodium hydroxide. The contents were then mixed with 50 mL of deionized water and extracted three times with 50 mL of diethyl ester, dried over anhydrous sodium sulphate and evaporated to near dryness. The residues were transferred to a screw-cap vial, flushed with nitrogen and placed in the freezer until analyzed on GLC. Two glass columns (90 cm long x 0.2 cm ID) were used. The columns were packed with 3% OV1 on 100-200 mesh chromosorb W A/W DMCS. Direct column injection was employed with temperature programming from 180-300°C at a rate of 8°/min. Injector and detector temperatures were 150°C and 300°C, respectively, and the same flow rates were used as in the methyl ester analysis. The identification of sterols was accomplished by matching corrected retention times with reference standards (Supelco Inc., Bellefonte, Penn.). TMS derivatives were also prepared using Tri-sil (BSA Pierce Chemical Co., Rockford, Ill.) as well as GC/MS using the Hewlett Packard system model 5990A.

Results and Discussion

Table 1 shows the proximate composition of both varieties of truffle tubers. It can be seen from this table that protein (expressed as N x 6.25) and fat content is

similar to most root crops. The moisture content of the white variety is somewhat higher than that of the black variety. These findings are similar to the data reported by Al-Delaimy (1977), who found the moisture content of the black and the white varieties of truffles to be 77.61% and 80.5%, respectively. The protein contents found in this study for both varieties were higher than the findings reported by the same author.

The lipids present in truffle tubers, even though of low concentration, possess an interesting profile. Figure 1 shows a typical GLC pattern of the fatty acids of the polar lipid fraction of truffle tubers. Table 2 shows the component fatty acids (weight %) of both neutral and polar lipid fractions in both varieties of truffle. The fatty acid composition appears to be typical of a plant product. The neutral lipid fractions in both varieties appear to be rich in linoleic acid amounting to 57.15% and 57.93% for black and white varieties, respectively. The total unsaturated fatty acids of C18 chain length amounted to 73.76% and 70.07% for black and white varieties, respec-

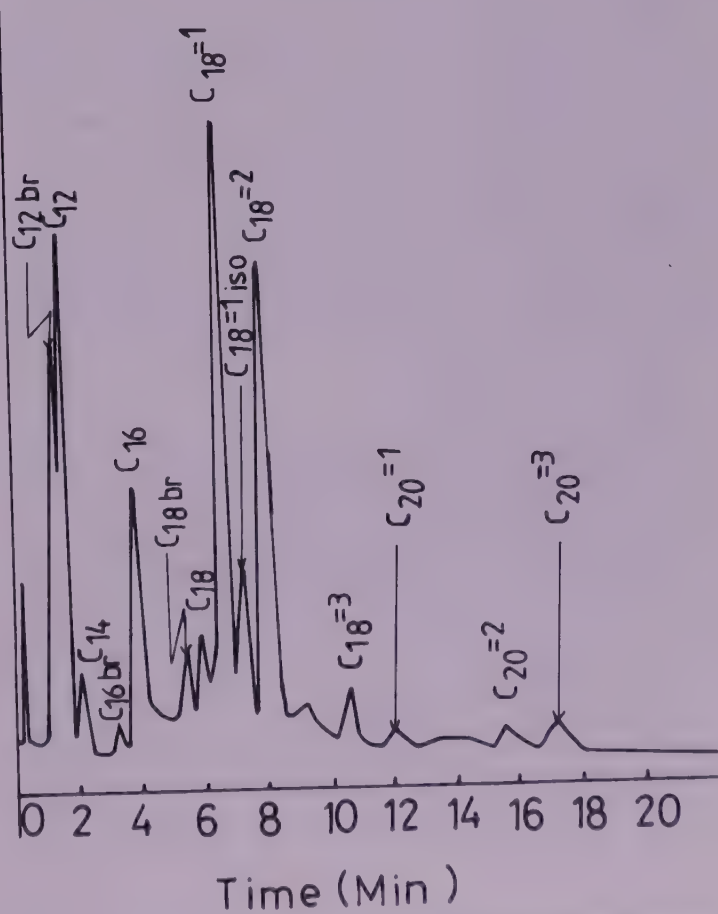


Fig. 1. Component fatty acid methyl esters of the polar lipids fraction in truffles as determined by GLC.

Table 2. Component fatty acids (weight %) of the neutral and polar lipid fractions from two varieties of Iraqi truffles as determined by GLC.

Fatty acids ¹	Black		White	
	Neutral lipids	Polar lipids	Neutral lipids	Polar lipids
C12br	—	4.37	—	5.60
C12	0.52	8.66	2.47	10.82
C14	0.43	2.25	0.20	2.29
C16br	—	1.25	—	0.61
C16	18.15	11.39	21.45	9.40
C16:1	1.04	—	0.90	—
C18br	1.35	5.01	0.10	4.10
C18	1.48	4.20	1.32	4.56
C18:1	14.09	24.94	11.01	33.78
C18:iso	—	6.45	—	—
C18:2	57.15	19.96	57.93	19.75
C18:3	2.52	4.25	1.13	4.03
C20:1	0.99	3.17	0.51	0.29
C20:2	—	1.91	—	0.57
C20:3	—	—	—	1.31

¹Fatty acids are represented by their carbon number, branching (br) and state of unsaturation (1 to 3); iso = trans isomer.

tively. However, the total saturated fatty acids (palmitic and stearic) amounted to 19.60% and 22.77% for black and white varieties, respectively. The presence of C12, C18br and C20:1 was evident in all samples analyzed. The polar lipid fractions differ considerably in their composition when compared with the neutral lipid fractions of the same variety of truffle tubers. Oleic acid represents the highest concentration of all other acids in the polar lipid fractions averaging 24.9% and 33.78% in black and white varieties, respectively. The total unsaturated fatty acids of C18 chain length amounted to 55.6% and 57.56% for black and white truffles, respectively. These figures are considerably lower than those for the neutral lipid fractions corresponding to the same varieties.

Figure 2 represents a GLC pattern of the sterols present in the black truffle. This pattern is a typical pattern for all sterol samples analyzed. β -sitosterol was the major sterol, accounting for 61.16% and 83.41%, while stigmasterol represents 6.31% and 5.01% for black and white truffles, respectively. Other components were not identified.

References

- Al-Delaimy, K.S. and Ali, S.H. 1970. Storage, spoilage and proximate food composition of Iraqi truffles. *Trop. Subtrop. landwirt., Tropenveterinarmedizin.* 8:77.
- Al-Delaimy, K.S. 1977. Protein and amino acid composition of Iraqi truffles. *Can. Inst. Food Sci. Technol. J.* 10:221.

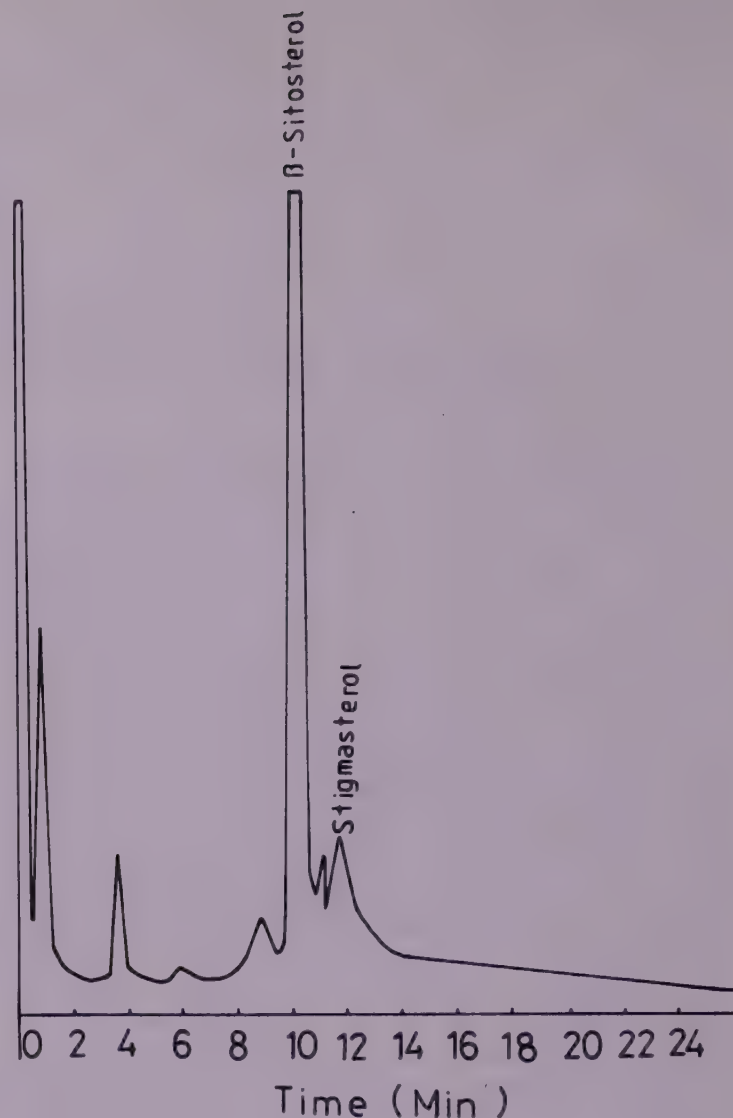


Fig. 2. GLC pattern of the sterols present in black truffles.

- AOAC. 1970. *Official Methods of Analysis*, 11th ed. Association of Official Agricultural Chemists, Washington, DC.
- Borgström, B. 1952. Investigation on lipid separation methods. Separation of phospholipids from neutral fat and fatty acids. *Acta Physiol. Scand.* 25:101.
- deMan, J.M. 1964. Determination of fatty acid composition of milk fat by dual column temperature-programmed gas liquid chromatography. *J. Dairy Sci.* 47:546.
- Morrison, W.R. and Smith, L.M. 1964. Preparation of fatty acid methyl esters and dimethylacetals from lipids with Boron Fluoride-Methanol. *J. Lipid Res.* 5:600.

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Functionality of Soy Proteins in Wheat Flour/Soy Isolate Doughs. I. Characterization of Isolates Prepared Using Different Isolation Procedures

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Abstract

Soy proteins prepared under laboratory conditions using different extraction media (water and alkali), different treatment in the separation of the isolated proteins (isoelectric precipitation and neutralization to form Ca, K and Na proteinates) and drying (freeze-, spray and drum drying) were subjected to chemical and physico-chemical testing in order to establish quantitatively the differences between their nature and their functional behaviour in protein supplemented wheat doughs. (Results of functionality tests will be reported in Part II.) Apart from chemical analysis (including reactive and total SH and SS groups) and N solubility tests, the isolates were compared on the basis of their gel filtration profiles and electrophoretic as well as ultracentrifugation patterns of their major globulin fraction. The tests revealed some consistent differences between the test proteins (e.g., higher SH and SS content in isoelectric protein than in proteinates, minor but consistent differences in the gel filtration profiles of the alkali and water extracted isolates, higher loose bulk density of the former); but water solubility and hydration capacity, measured in terms of both water absorption and retention, gave expectedly the most marked indication of sufficient variability in the nature of the isolated samples for further testing of their functionality.

Résumé

Des protéines de soja furent préparées en laboratoire par différents milieux d'extraction (eau et alcali), différents traitements pour la séparation des protéines isolées (précipitation isoélectrique et neutralisation pour former des protéinates de calcium, de potassium et de sodium) et différents moyens de séchage (lyophilisation, pulvérisation et séchage sur cylindres). Elles furent étudiées à l'aide de tests chimiques et physico-chimiques dans le but d'établir quantitativement les différences entre leur nature et leur comportement fonctionnel lorsqu'ajoutées à des pâtes de blé. (Les résultats des tests de fonctionnalité sont rapportés à la Partie II.) En plus des analyses chimiques (incluant les groupements SH et SS réactifs et totaux) et des tests de solubilité des constituants azotés, les isolats furent comparés sur la base de leurs profils de filtration sur gel et des spectres électrophorétiques et d'ultracentrifugation de

leur principale fraction globuline. Les tests ont révélé des différences constantes entre les protéines étudiées (e.g., teneur SH et SS plus forte chez les protéines isoélectriques que chez les protéinates, différences mineures mais constantes dans les profils de filtration sur gel des isolats extraits à l'alcali et ceux extraits à l'eau, densité volumétrique lâche plus élevée du premier). La solubilité aqueuse et le pouvoir d'hydratation mesuré en termes d'absorption et de rétention d'eau, ont donné, tel qu'espéré; l'indication la plus prononcée de variabilité suffisante dans la nature des échantillons isolés pour en justifier l'étude plus approfondie de leur fonctionnalité.

Introduction

Supplementation of wheat flour with high protein material to increase protein content and to improve essential amino acid balance of various bakery products has been recognized for some years. As improvements in nutritive value can only be considered successful if a product with visual, textural and organoleptic qualities acceptable to the consumer is produced, functional properties of various protein supplements have been the focus of interest of many researchers and technologists. Although many different plant proteins have been studied and used, soy protein still remains the most widely investigated supplement (Ofelt *et al.*, 1954a,b; Finney *et al.*, 1963; Paulsen and Horan, 1965; Pomeranz, 1966; Mizrahi *et al.*, 1967; Tsen and Tang, 1971; Rooney *et al.*, 1972; Marnett *et al.*, 1973; Tsen and Hoover, 1973; Fleming and Sosulski, 1974, 1977; Ranhotra *et al.*, 1974; Sipos *et al.*, 1974; Onayemi and Lorenz, 1978; Khan and Lawhon, 1980). Most of the reported work focused on the use of soy flour or soy protein concentrates. Relatively few reports are available on the functionality in bakery products concerned with soy protein isolates. In many of the reported studies or reviews the nature of the tested material, as primarily determined by the preparative treatment, was not revealed.

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The present work was undertaken to provide more information on the functionality of soy protein in bakery products by a systematic study on laboratory prepared isolates with analytically established characteristics. In order to obtain material with a sufficient variation in chemical and physical properties, the isolates were prepared from the same source under different conditions of extraction (water and alkali extraction), protein curd treatment (isoelectric protein, neutralization to form Ca, K and Na proteinates) and drying (freeze-, spray and drum drying). The bearing of preparative conditions on the nature of the isolated protein has been well recognized and comprehensively discussed in numerous literature sources (Wolf, 1969; Lawrie, 1970; Smith and Circle, 1972). It should, therefore, be pointed out that testing of the isolated material for its chemical and physical properties, as reported in this study, was not conducted with the objective of generating any additional information on this particular subject. All data presented in Part I of this paper were collected as evidence for the qualitative differences between the tested material. They served as a basis for a quantitative evaluation of the relationships between the varying properties of the isolates, and the functional performance data obtained in tests on wheat flour/soy protein mixtures which will be discussed in Part II.

Materials and Methods

Preparation of the Isolates

Ontario grown soy beans were dehulled and ground to grits in a Palyi compact dehulling unit (deMan *et al.*, 1973). After 8 h extraction with hexane, the grits were reground to pass through a No. 24 mesh screen and the extraction was repeated. Defatted grits were then pulverized in a laboratory mill (Weber Bros. and White Metal Workers, Inc., Chicago, Ill.) to pass through a No. 60 mesh screen. To isolate protein, an outline of commercial isolation (Wolf, 1969) was followed. The defatted and pulverized material was extracted with either distilled water or 0.01 N NaOH for 1 h under constant stirring using a 1:20 meal:liquid ratio. Two successive extractions were performed. The supernatant obtained after centrifugation of the slurry at 1,000 rpm for 20 min was acidified to pH 4.5 with 0.1 N HCl. Protein curd was thoroughly washed with deionized water and was freeze-dried in either the isoelectric form or, after adjustment of the pH to about 7, in the form of Ca, K or Na proteinates. Freeze-drying was carried out in a laboratory freezer drier (RePP, The Virtis Co., Inc., Gardiner, N.Y.) with a shelf temperature of 38°C. Apart from freeze-drying, spray drying and drum drying were applied with the alkali extracted Na proteinate. Spray drying was conducted in a pilot plant spray drier (Swenson Laboratory Research Spray Drier). Prior to spray drying, the samples were heated to 49°C. Drying conditions, in terms of inlet and outlet temperatures, were 191°C and 107°C, respectively. The air pressure on the feed and the fluid nozzle was 12 and 14 psi, respectively. For drum drying, a laboratory double drum drier was used (drum diameter 21.8 cm, drum length 14.6 cm, drum speed 2.5 rpm, temperature of steam 134°C). Dried isolates, with the exception of the spray dried Na proteinate, were

pulverized to pass through a No. 60 mesh screen and stored at 4°C until used.

Analytical Methods

Moisture, crude fibre, protein (N x 5.70) and ash were determined using AACC (1969) methods. Free lipids were extracted by 12 h extraction in a Soxhlet apparatus with petroleum ether (b.p. 35-60°C). Bound lipids in the residue were determined by extraction with water saturated n-butanol as described by Pomeranz *et al.* (1966). Measurement of pH was performed on suspensions of the isolates in distilled water (1 g in 20 mL) at 20°C.

Sulphydryl and Disulphide Groups

Both sulphydryl and disulphide groups were determined by argentometric amperometric titration as described by Bloksma (1958). Instead of calomel electrode, an Orion double junction reference electrode Model 90-02 (Orion Research, Inc., Cambridge, Mass.) with 10% KNO₃ was used, at working potential +0.35 V. In order to distinguish between the easily reactive and total groups, titrations were performed both in the presence and absence of the disaggregating reagent (urea). Under the latter conditions, only the easily reactive groups were determined.

Nitrogen Solubility

Carmody's approximate universal buffer (Carmody, 1961) was used for preparing the pH range from 1.0-12.0. Sodium chloride was added to adjust the ionic strength of the buffer to $\mu = 0.5$. The extraction was carried out at 25°C under constant stirring for 2 h using a 1:20 meal:liquid ratio. The slurry was centrifuged for 30 min (5°C) at 1,870 g. The extraction was repeated twice and nitrogen in combined supernatants was determined by microKjeldahl method (AOAC, 1975).

Gel Filtration and Disc Gel Electrophoresis

Approximately 25 mg protein was layered on the top of the Bio-Gel P-150 column (100 x 2 cm with a final bed volume of 450 mL) and eluted with standard buffer (potassium phosphate-sodium chloride, pH 7.6, $\mu = 0.5$). A volume of 5 mL/tube was collected at the rate of 10 mL/h; the elution was monitored spectrophotometrically at 280 nm. The column was calibrated with the following standards: aldolase (MW = 158,000), bovine serum albumin (MW = 69,000), ovalbumin (MW = 45,000), chymotrypsinogen (MW = 25,000) and ribonuclease A (MW = 13,700).

Eluate from the void volume of the column corresponding to peak No. 1 was pooled, freeze-dried and further fractionated by electrophoresis on 7% acrylamide gel using a Model 1200 Canaco Disc Electrophoresis with Model 300 power source. Approximately 200 μ g protein was applied to the gel. The gels were stained for 1 h with aniline blue-black and destained in a Canaco Model 1801 Quick Gel Destainer. They were then scanned in a Joyce-Loebl Chromoscan densitometer at 620 nm.

Ultracentrifugation Studies

The procedure was in principle as described by Naismith (1955). The sample was dispersed in the standard potassium phosphate-sodium chloride buffer (pH 7.6, $\mu = 0.5$) to get a solution of approximately 15 mg protein/mL. The dispersions were equilibrated by dialysis with stirring, at 4°C, against buffer for 48 h. The solution was centrifuged

at 15,000 rpm for 10 min at 4°C in order to remove any fine particles. A 0.5 mL aliquot was then filled into a double sector cell and centrifuged in a Beckman Model E analytical ultracentrifuge using a Schlieren optical system. The centrifugation pattern was taken 21 min after the centrifuge reached its maximum speed of 56,000 rpm. The sedimentation coefficients (S) were calculated according to a procedure described by Tanford (1963).

Loose Bulk Density

Loose bulk density was measured with a Scott paint volumeter (Fisher Scientific Co., Limited, Cat. No. 13-335).

Water Absorption and Water Retention

For the water absorption test, a 50 mg sample was evenly distributed in a thin layer on a Millipore AA 0.80 µm membrane which was placed on a fritted glass plate of the Baumann's capillary apparatus (Baumann, 1967; Rasper and deMan, 1980). Water uptake by the sample at 25°C was read directly from the position of the meniscus on the capillary scale of the apparatus. Water absorption was expressed as the amount of water in mL taken by 1 g of dry solids after 10 min contact time.

Water retention was determined as the amount of water retained by the sample (1 g) against a centrifugal force of 20,000 g (15 min) after 2 h hydration at 25°C in distilled water under constant shaking. The water retention values were corrected for loss of solubles during hydration (see water solubility test).

Water Solubility

An aliquot of the supernatant remaining following the water retention test was pipetted into a drying dish, and after water was evaporated over a steam bath, the dish was kept in a vacuum oven (40°C) until a constant weight was reached. Solubility was calculated as the percent solids dissolved from 1 g dry solids of the sample under the conditions of test.

Emulsifying Capacity

To prepare emulsions, 6 mL of corn oil stained with Sudan red IV and 20 mL of protein solution in 0.01 M

phosphate buffer (pH 7.6) were mixed and homogenized in a Sorvall Omnimixer at the speed setting of five for 1 min at 20°C. The emulsion (15 mL) was poured into a 15 mL graduated centrifuge tube and centrifuged at 800 g for 3 min. The volume of the separated aqueous phase was measured.

Results and Discussion

Yield, Proximate Analyses and Bulk Density

The average yields of water and alkali extracted isolates were 41.3% and 48.3% (spray dried Na proteinate not included), respectively (Table 1). These yields, based on the dry solids of the dehulled and defatted soy grits, agreed well with those of Smith (1958) who reported an average yield of 42% under laboratory conditions; a 30% yield is considered good for commercial operations.

Table 1 also gives proximate analyses of all tested isolates. A narrow range of protein values (80.5-82.1%) provided conditions minimizing any variations in the functional behaviour of the test material which could possibly arise from the varying content of this principle constituent. The values were found slightly below those of commercial isolates, for which Smith and Circle (1972) gave a range between 88% and 93% (based on dry solids, N x 5.70). On the other hand, ether extractable lipids were determined in quantities higher than those usually present in the commercial preparations, presumably due to a rather high residual fat content (3.5%) in the hexane extracted soy grits used as starting material. Free lipid values for isoelectric protein, both water and alkali extracted, exceeded those for other isolates, but total lipid values for all freeze- and spray dried isolates were found in a relatively narrow range. Complex aggregation reactions taking place during drum drying may be responsible for a markedly reduced lipid extractability of the drum dried Na proteinate under the conditions of test.

Expectedly, neutralization of the isolated protein curd into the form of proteinates resulted in a markedly higher ash content compared with that of the isoelectric protein.

Table 1. Yield, loose bulk density and proximate analyses of soy isolates. (All analytical data expressed on dry solids of the analyzed material.)

Sample	Yield (%)	Loose bulk density (g/mL)	pH	Protein (%)	Free lipids (%)	Bound lipids (%)	Ash (%)	Crude fibre (%)
Water extracted isolates: ¹								
Isoelectric protein	40.6	0.45 ²	4.93	82.13	0.97	6.95	0.88	0.15
Ca proteinate	42.6	0.36	7.00	81.55	0.68	7.66	4.85	0.18
K proteinate	41.9	0.19	7.00	81.21	0.44	8.01	6.22	0.16
Na proteinate	40.1	0.21	7.07	82.06	0.58	7.84	4.20	0.16
Alkali extracted isolates: ¹								
Isoelectric protein	48.5	0.47	4.90	81.82	1.61	6.79	1.75	0.15
Ca proteinate	49.7	0.39	6.99	80.45	0.67	7.68	5.18	0.20
K proteinate	50.3	0.27	7.06	80.49	0.39	8.64	6.60	0.20
Na proteinate	48.6	0.23	7.10	80.92	0.63	8.29	4.36	0.22
Na proteinate (spray dried)	40.6	0.12	7.10	81.32	0.37	7.35	4.36	0.20
Na proteinate (drum dried)	44.4	0.51	7.34	81.25	0.48	2.00	4.30	0.20

¹Unless otherwise stated, the isolates were prepared by freeze-drying.

²All data are means of at least duplicate determinations (except of yield).

Similarly, the ash content was affected by the type of extraction medium; the ash values for alkali extracted material were on average 0.5% higher than those for the water extracted ones. Low quantities of crude fibre not exceeding 0.2% were found in all isolates.

There was a consistent trend shown by the bulk density in dependence on the type of preparative treatment. The values for alkali extracted isolates exceeded by 13% on average those recorded with the water extracted ones. Isoelectric protein appeared to have the highest bulk density, followed by Ca proteinate. The lowest values were obtained with all alkali metal (Na, K) proteinates. It may, however, be noticed that drying rather than isolation technique had a more pronounced effect on this property, as evidenced by considerable variation in values for Na proteinates subjected to different drying treatments. The differences in bulk density may be of minor significance, but since they are related not only to the differences in the actual density of the isolate but also to its particle size characteristics, bulk density may be considered to have some influence on properties such as water absorption where granularity may play an important role (Betschart *et al.*, 1975).

Sulphydryl and Disulphide Groups

Isoelectric precipitation of extracted protein apparently promotes polymerization by disulphide linking, which results in formation of insoluble polymers. Formation of these polymers may also be promoted by the addition of small amounts of some salts (Kuramoto, 1966; Wolf, 1969). Isolates with a higher degree of this polymerization are claimed to perform better in bakery products than isolates which presumably contain free sulphydryls capable of reacting with wheat gluten forming proteins. The extent of disulphide linking in the isolate will depend on the conditions under which the isolate was prepared. In analyzing the test isolates (Table 2), significantly higher quantities of SH groups were found in the isoelectric protein than in any of the tested proteinates.

It should, however, be noted that isoelectric protein also gave the highest values for disulphide groups. This observation may therefore lead to a suggestion that neutralization of the protein curd reduced the total content of sulphur containing fraction rather than influencing the formation of additional disulphide links.

With the exception of drum dried Na proteinate, all isolates were characterized by practically identical values for both reactive and total sulphydryl groups. On the other hand, reactive disulphide groups of all freeze-dried and spray dried isolates represented only 30-40% of the total. Drastic changes in both sulphydryl and disulphide groups resulted from a higher degree of heat treatment during drum drying, as shown by values for drum dried Na proteinate.

Nitrogen Solubility

It is understood that N solubility of the isolated protein will depend on many factors including not only the conditions of preparation but also of storage and testing (Nash and Wolf, 1967; Shen, 1976). In spite of a great variability in this property, conditions of the preparative technique play a predominant role, and N solubility of the isolate may be predicted to a great extent on the basis of the treatment applied. As expected, when N solubility of the tested isolates was measured as a function of varying pH under constant ionic strength ($\mu = 0.5$), the highest values were recorded with alkali metal proteinates, whereas the lowest ones appeared on the N solubility curves of isoelectric protein and Ca proteinate (Figure 1). The differences between these two classes of isolates were even more noticeably demonstrated by their response to the changing ionic strength under the conditions of constant pH (Figure 2). At close to zero ionic strength, both K and Na proteinates displayed a high N solubility followed by a sharp drop as the ionic strength reached the range of $\mu = 0.05-0.1$. After a moderate recovery on reaching $\mu = 0.5$, there was a steady decrease in the measured property with increasing ionic

Table 2. Sulphydryl and disulphide groups in tested soy protein isolates. Results of amperometric titration expressed as $\mu\text{M/g}$ dry solids.

Sample	Sulphydryl groups				Disulphide groups			
	Reactive ¹		Total		Reactive ¹		Total	
Water extracted isolates: ²								
Isoelectric protein	5.57a	(0.13) ³	6.67	(0.13)	8.82	(0.04)	24.20	(0.13)
Ca proteinate	4.75b	(0.03)	4.66ab	(0.13)	6.48	(0.39)	22.46	(0.04)
Na proteinate	4.47c	(0.06)	4.75a	(0.14)	9.13b	(0.37)	23.18b	(0.14)
K proteinate	4.65b	(0.13)	4.74a	(0.02)	7.75	(0.13)	21.78	(0.13)
Alkali extracted isolates: ²								
Isoelectric protein	5.22a	(0.13)	5.22	(0.11)	10.07a	(0.26)	26.37	(0.26)
Ca proteinate	4.43c	(0.13)	4.43b	(0.12)	9.30b	(0.13)	23.29b	(0.14)
Na proteinate	4.38b	(0.06)	4.38b	(0.06)	10.02a	(0.22)	23.97c	(0.13)
K proteinate	4.73b	(0.25)	4.82a	(0.13)	9.64	(0.01)	24.20ac	(0.52)
Na proteinate (spray dried)	5.21a	(0.02)	4.84a	(0.03)	8.28	(0.24)	25.45	(0.06)
Na proteinate (drum dried)	2.61	(0.01)	4.84a	(0.12)	1.81	(0.07)	27.82	(0.14)

¹Measured in the absence of disaggregating agent (urea).

²Unless otherwise stated, the isolates were prepared by freeze-drying.

³All data are means (standard deviation) of four replicates. Means in the vertical columns not followed by the same letter are significantly different ($P < 0.05$) using Duncan's multiple range test.

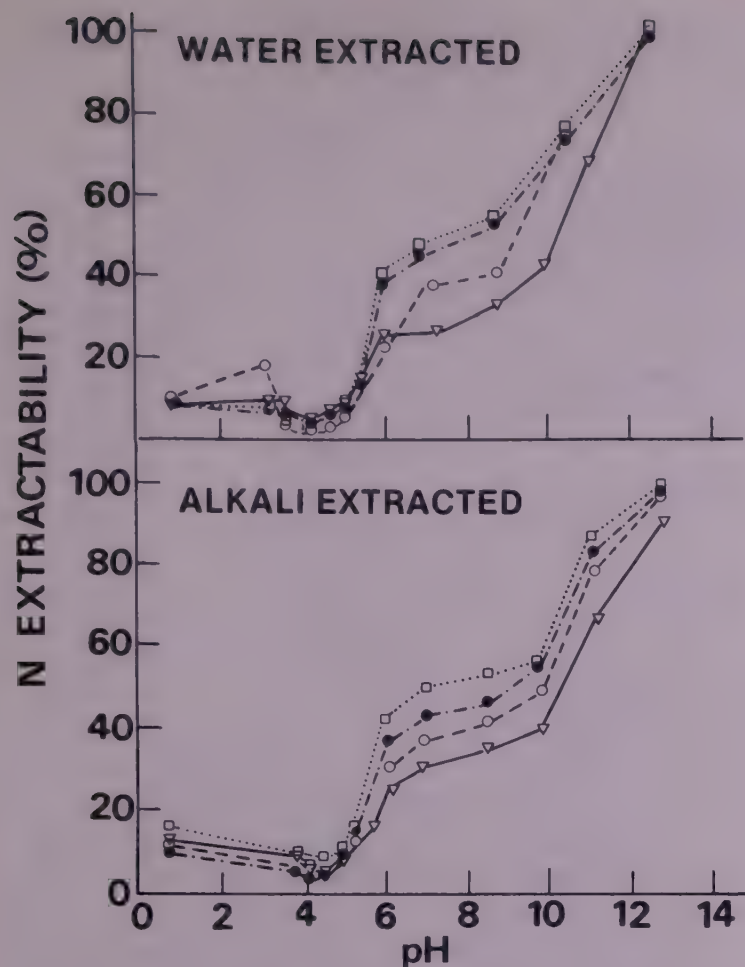


Fig. 1. Nitrogen solubility of freeze-dried isolates at constant ionic strength ($\mu = 0.5$).

- isoelectric protein
-□ Na proteinate
- .-.-● K proteinate
- ▽-----▽ Ca proteinate

strength. The response pattern shown by Ca proteinate and isoelectric protein was different. Their N solubility at the ionic strength close to zero was very low. It sharply increased to reach a maximum at $\mu = 0.5$, but it still remained distinctly below the N solubility values for the alkali metal proteinates. As for the effect of the extraction medium used in the preparation of the isolates, the curves showed a consistently lower solubility of alkali extracted isolates compared with the water extracted ones.

In evaluating the results on proteinates after different drying treatment, the freeze-dried and spray dried proteins were found in a very close range of N solubilities over the whole pH range applied. N solubility of the drum dried Na proteinate was very low, up to pH 11, when it sharply increased (Figure 3). In contrast to the other two proteinates, its N solubility did not seem to be affected by changing ionic strength (curves not shown).

Gel Filtration, Electrophoresis and Ultracentrifugation

The gel filtration profiles revealed more differences between the individual tested isolates (Figure 4a,b,c). Peak No. 2, representing a protein fraction with a molecular weight of approximately 69,000, was absent from all gel filtration profiles of alkali extracted samples.

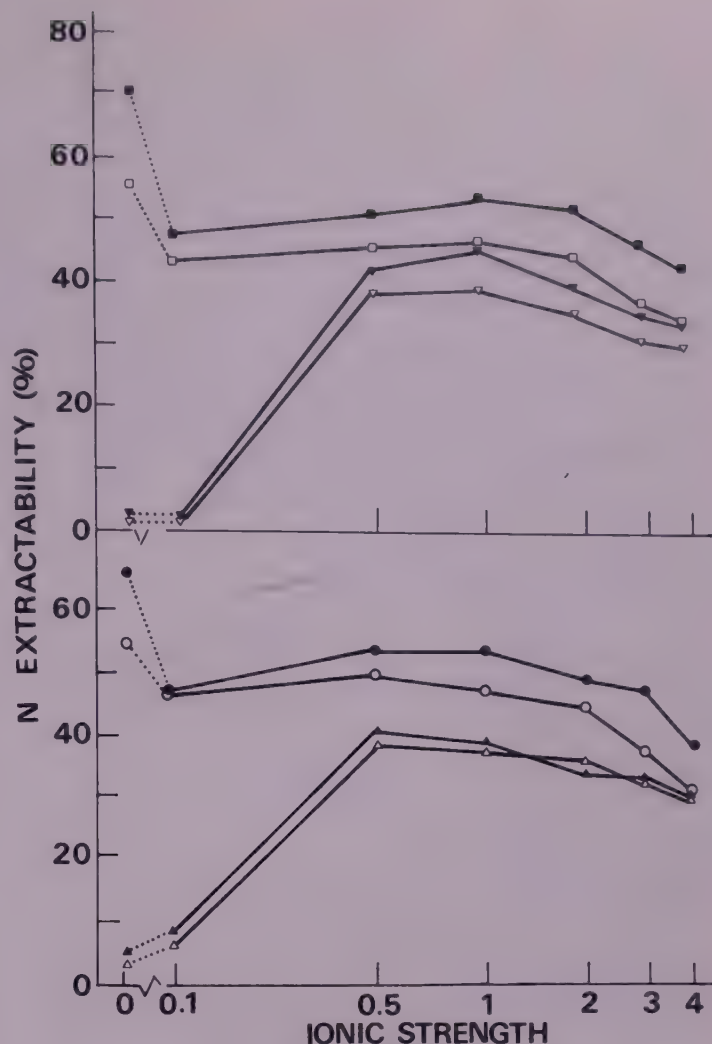


Fig. 2. Nitrogen solubility of freeze-dried isolates at varying ionic strength (pH 7.6).

- | | |
|-----------------------|-----------------------|
| Water extracted | Alkali extracted |
| ▽ isoelectric protein | ▽ isoelectric protein |
| △ Ca proteinate | △ Ca proteinate |
| ■ K proteinate | □ K proteinate |
| ● Na proteinate | ○ Na proteinate |

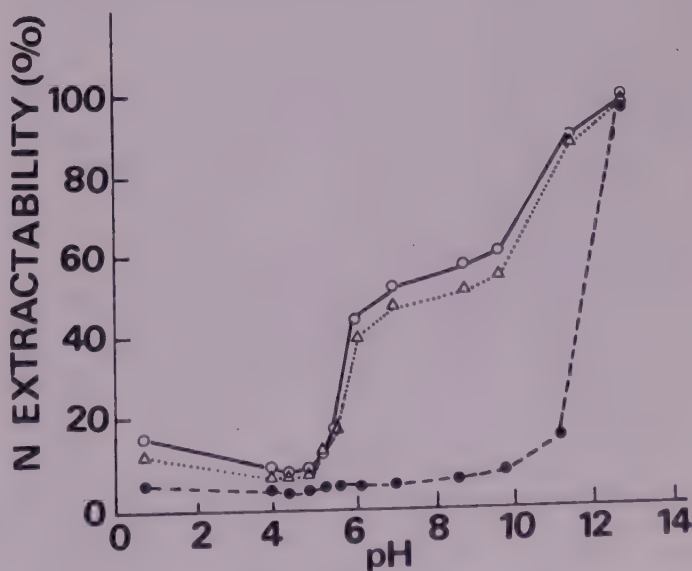


Fig. 3. Nitrogen solubility of Na proteinate at constant ionic strength ($\mu = 0.5$).

- spray dried
- △.....△ freeze-dried
- .-.-● drum dried

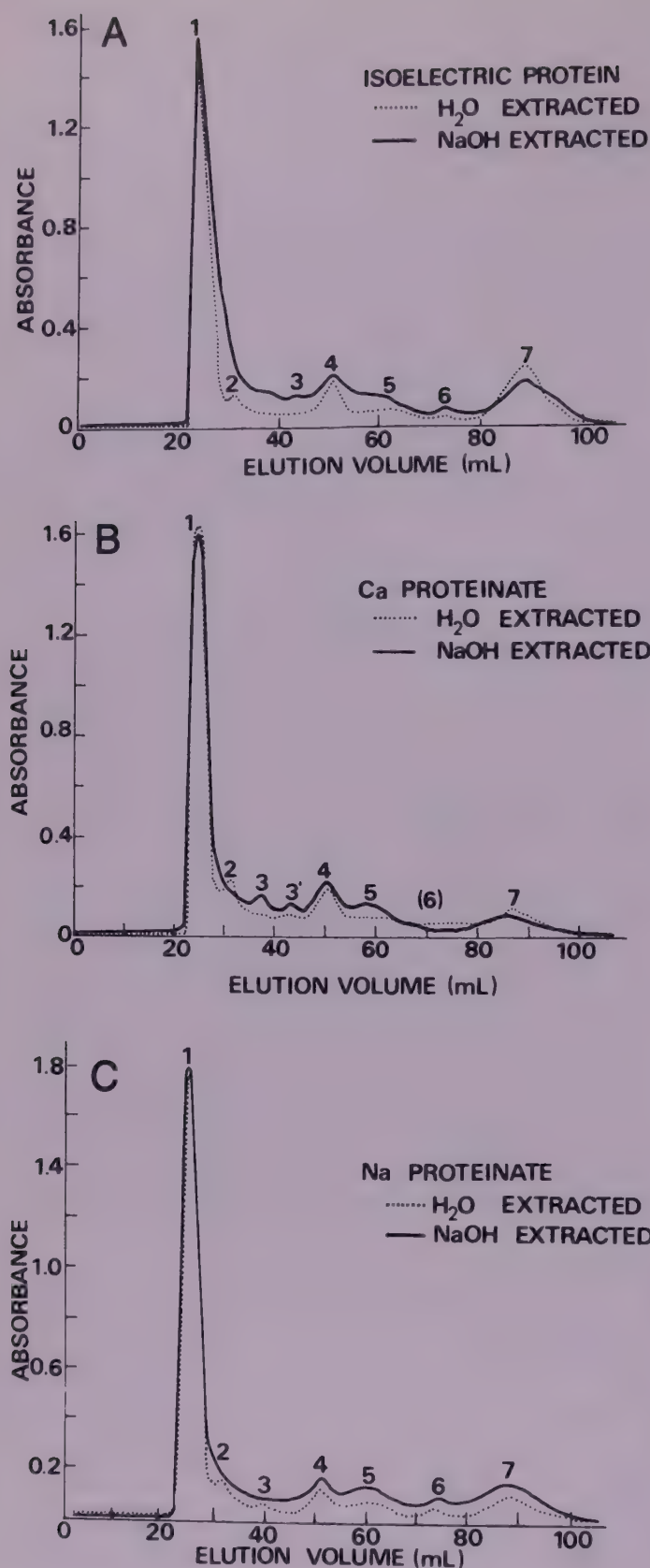


Fig. 4. Gel filtration profiles (Bio-Gel P-150) of freeze-dried isolates with 5 mL fractions.

Minor differences were also observed between the individual forms of isolated protein. Isoelectric protein was characterized by a distinctly higher peak in the region of molecular weight far below 20,000 (peak No. 7), while the lowest peak in this region appeared on the profile of Ca proteinate. This proteinate was also characterized by the absence of peak No. 6 and a more distinct appearance of peaks No. 3 and 3' (molecular weights of approxi-

Table 3. Sedimentation coefficients and quantitative evaluation of ultracentrifugation patterns of soy protein isolate fraction eluted from void volume of Bio-Gel P-150 column.

Sample	Sedimentation coefficient (S)	Quantity (%)
Isoelectric protein ¹ (water extracted)	6.77	25.37
	10.62	55.59
	15.21	13.80
	17.91	5.25
Isoelectric protein (alkali extracted)	6.36	37.14
	10.50	57.99
	15.28	4.86
Ca proteinate (water extracted)	7.01	24.85
	10.85	66.55
	16.01	8.60
Na proteinate (water extracted)	6.54	28.18
	11.03	55.35
	15.83	16.46

¹ All samples freeze-dried.

mately 45,000 and 55,000, respectively) than could be observed on the profiles of other isolates. Peak No. 4 (molecular weight of approximately 25,000) was detectable on all profiles.

Some of the ultracentrifugation patterns of the major globulin fraction eluted from the void volume of the Bio-Gel P-150 column (peak No. 1) are presented in Figure 5. They all showed three peaks (7S, 11S and 15S), with the exception of water extracted isoelectric protein, which was the only one yielding 17S peak ($S = 17.19$). There were, however, some differences in the quantitative distribution of the individual fractions (Table 3). Among the water extracted isolates, the most soluble Na proteinate appeared to have a considerable higher portion of the 15S fraction than Ca proteinate or isoelectric protein.

Examples of the electrophoretic evaluation of the same gel filtration fraction (peak No. 1) are presented in Figures 6 and 7. Figure 6 presents electrophoretic profiles of this fraction obtained by gel filtration of Ca proteinate

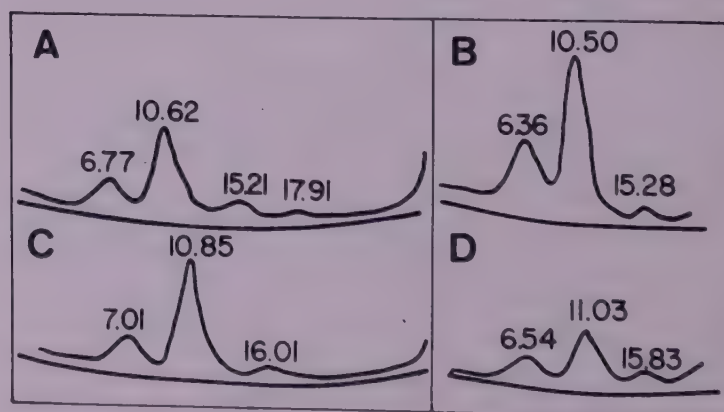


Fig. 5. Ultracentrifugation patterns of freeze-dried isolate protein eluted from the void volume of Bio-Gel P-150 column. Sedimentation coefficients are given above peaks. A - isoelectric protein (water extracted); B - isoelectric protein (alkali extracted); C - Ca proteinate (water extracted); D - Na proteinate (water extracted).

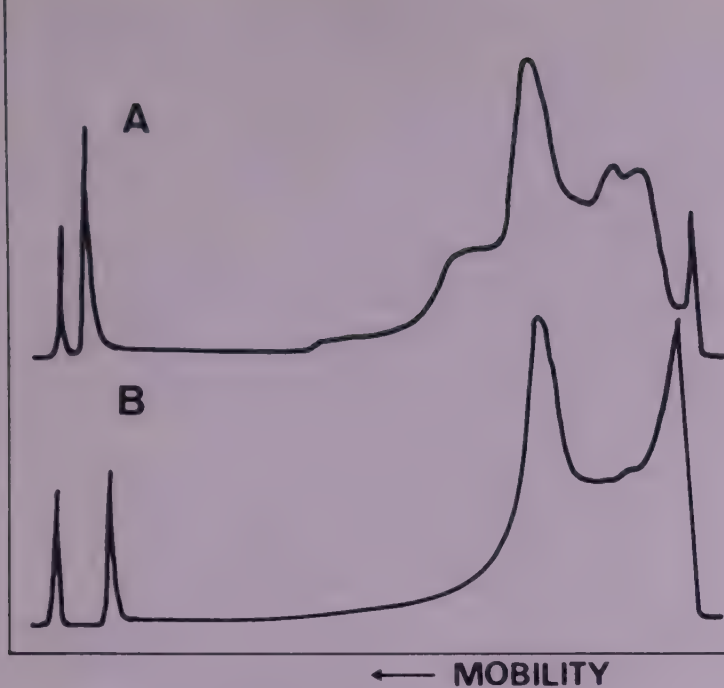


Fig. 6. Electrophoretic patterns of water and alkali extracted soy proteins eluted from the void volume of Bio-Gel P-150 column. A – water extracted; B – alkali extracted.

and Na proteinate, whereas Figure 7 compares profiles of the same fraction prepared by gel filtration of unprecipitated protein extracted from defatted soy flour with water or alkali. From comparing these two diagrams, it became evident that the electrophoretic profile of this particular gel filtration fraction changed during the precipitation and neutralization steps, but was more strongly affected by the extraction medium rather than by the type of alkali used in its neutralization.

Functional Properties

Among the many functional properties of soy protein, moisture binding and emulsifying seem to be the most relevant in bakery applications. Comparison of the tested

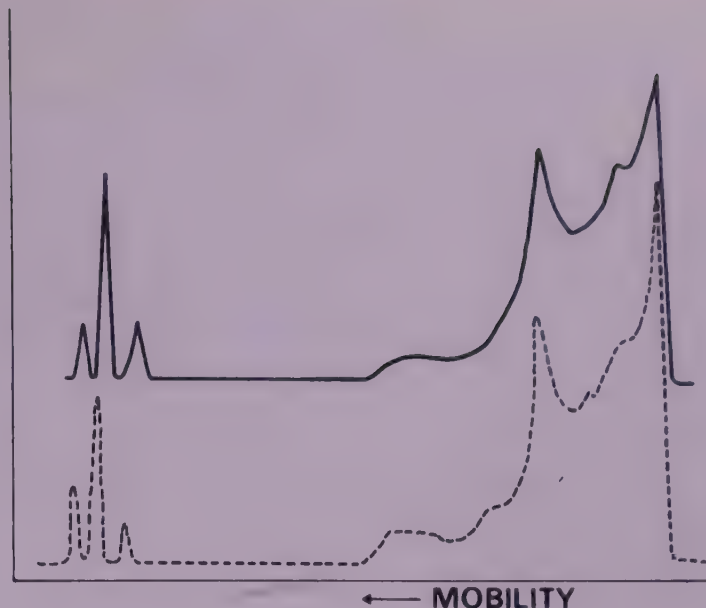


Fig. 7. Electrophoretic patterns of freeze-dried Ca proteinate and Na proteinate (both water extracted) eluted from the void volume of Bio-Gel P-150 column.

———— Ca proteinate
 ----- Na proteinate

isolates with respect to these two properties, as well as their solubility in water dispersions, is provided in Table 4. Expectedly, both isoelectric protein and Ca proteinate differed markedly from the alkali metal proteinates in their hydration capacity and solubility. The effect of extraction medium was also noticeable. Both water absorption values measured with the Baumann's capillary apparatus, and uncorrected water retention values tended to be higher for the water extracted material than for the alkali extracted material. This relationship became ambiguous after the water retention data were corrected for losses due to water solubility of the tested samples. Water solubility data showed the differences between the isolates most distinctly, but compared to water absorp-

Table 4. Properties of tested isolates.

Sample	Water solubility (%)		Water absorption (mL/g)		Water retention				Emulsifying (mL/g)	
					Uncorrected (g/g)		Corrected (g/g)			
Water extracted isolates: ¹										
Isoelectric protein	0.76a	(0.20) ²	0.64a	(0.06)	1.48e	(0.15)	1.50b	(0.04)	9.3b	(0.4)
Ca proteinate	3.93b	(0.15)	0.50	(0.07)	1.94c	(0.20)	2.02b	(0.21)	9.6ab	(0.8)
K proteinate	61.96	(0.70)	2.19cd	(0.09)	5.93ab	(0.46)	15.60a	(0.18)	9.3b	(0.3)
Na proteinate	64.16	(0.92)	2.52de	(0.14)	5.50b	(0.30)	15.35a	(0.48)	9.6ab	(1.0)
Alkali extracted isolates: ¹										
Isoelectric protein	0.89a	(0.15)	1.32b	(0.08)	1.52ce	(0.10)	1.54b	(0.09)	9.5ab	(0.8)
Ca proteinate	3.93b	(0.44)	1.97b	(0.20)	1.99c	(0.08)	2.07b	(0.08)	10.4a	(0.7)
K proteinate	55.79c	(0.62)	2.75ef	(0.04)	6.42a	(0.19)	14.52a	(0.72)	9.2b	(0.7)
Na proteinate	55.81c	(0.78)	2.99f	(0.36)	6.00ab	(0.13)	13.69a	(0.09)	10.3a	(0.8)
Na proteinate (spray dried)	58.47	(1.40)	1.99bc	(0.11)	6.07ab	(0.15)	14.66a	(0.41)	9.6ab	(0.4)
Na proteinate (drum dried)	8.47	(0.35)	1.74b	(0.06)	4.34	(0.18)	4.75	(0.23)	9.1b	(0.9)

¹Unless otherwise stated, all isolates were freeze-dried.

²All data are means (standard deviation) of four replicates. Means in the vertical columns not followed by the same letter are significantly different ($P < 0.05$) using Duncan's multiple range test.

tion or retention (uncorrected) data, they responded to the type of extraction medium in an opposite way.

Differences between the emulsifying data were not great enough to manifest any trend.

The authors would like to point out again that all the above reported tests were performed with the intention to provide sufficient information on the experimental material, which was later used in supplemented wheat flour/soy protein blends. The behaviour of these blends during the process of dough making and bread baking will be discussed in Part II.

Acknowledgements

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References

- AACC. 1969. Approved Methods. American Association of Cereal Chemists, St. Paul, MN.
- AOAC. 1975. Official Methods of Analysis, 12th ed. Association of Official Analytical Chemists, Washington, DC.
- Baumann, H. 1967. Apparatur nach Baumann zur Bestimmung der Flüssigkeitsaufnahme von pulverigen Substanzen. Glas. Inst. Tech. Fachz. Lab. 11:540.
- Betschart, A.A., Saunders, R.M. and Kohler, G.O. 1975. Effects of processing on the baking quality of wet alkaline process wheat protein concentrate. Cereal Chem. 52:812.
- Bloksma, A.H. 1958. Die Bedeutung von Thiol- und Disulfidgruppen in Kleber für die Backfähigkeit. Getreide Mehl 8(9):65.
- Carmody, W.R. 1961. An easily prepared wide range buffer series. J. Chem. Educ. 38:559.
- deMan, J.M., Banigo, E.O.I., Rasper, V.F., Gade, H. and Slinger, S.J. 1973. Dehulling of sorghum and millet with Palyi compact milling system. Can. Inst. Food Sci. Technol. J. 6:188.
- Finney, K.F., Rubenthaler, G. and Pomeranz, Y. 1963. Soy-products variables affecting bread baking. Cereal Sci. Today 8:166.
- Fleming, S.E. and Sosulski, F.W. 1974. Dough conditioners in wheat-soy-gluten breads. Can. Inst. Food Sci. Technol. J. 7:51.
- Fleming, S.E. and Sosulski, F.W. 1977. Breadmaking properties of four concentrated plant proteins. Cereal Chem. 52:1124.
- Khan, M.N. and Lawhon, J.T. 1980. Baking properties of oilseed protein and isolate produced with industrial membrane system. Cereal Chem. 57:433.
- Kuramoto, S. 1966. Preparation of yeast-raised bakery products utilizing an isolated soy protein. U.S. Patent 3,252,807.
- Lawrie, R.A. 1970. Proteins as Human Food. AVI Publishing Company, Inc., Westport, CT.
- Marnett, L.F., Tenney, R.J. and Barry, V.D. 1973. Methods of producing soy-fortified bread. Cereal Sci. Today 18:30.
- Mizrahi, S., Zimmerman, G., Berk, Z. and Cogan, U. 1967. The use of isolated soybean proteins in bread. Cereal Chem. 44:193.
- Naismith, W.E.F. 1955. Ultracentrifuge studies on soy bean protein. Biochem. Biophys. Acta 16:203.
- Nash, A.M. and Wolf, J.W. 1967. Solubility and ultracentrifugal studies on soybean globulins. Cereal Chem. 44:183.
- Ofelt, C.W., Smith, A.K. and Derges, R.E. 1954a. Baking behaviour and oxidation requirements of soy flour. I. Commercial full-fat soy flours. Cereal Chem. 31:15.
- Ofelt, C.W., Smith, A.K. and Mills, J.M. 1954b. Baking behaviour and oxidation requirements of soy flour. II. Commercial defatted flours. Cereal Chem. 31:23.
- Onayemi, O. and Lorenz, K. 1978. Soy concentrate and soy isolate in bread baking. Baker's Dig. 54(1):18.
- Paulsen, T.W. and Horan, F.E. 1965. Functional characteristics of edible soy flours. Cereal Sci. Today 10:14.
- Pomeranz, Y. 1966. High-protein supplements in breadmaking. Baker's Dig. 40(3):44.
- Pomeranz, Y., Chung, O.K. and Robinson, R.J. 1966. The lipid composition of wheat flours varying widely in bread-making potentialities. J. Am. Oil Chem. Soc. 43:45.
- Ranhotra, G.S., Loewe, R.J. and Lehman, T.A. 1974. Bread-making characteristics of wheat flour fortified with various commercial soy protein products. Cereal Chem. 51:629.
- Rasper, V.F. and deMan, J.M. 1980. Measurement of hydration capacity of wheat flour/starch mixtures. Cereal Chem. 57:27.
- Rooney, L.W., Gustavson, C.B., Clark, S.P. and Clark, C.M. 1972. Comparison of baking properties of new soy protein isolate. Cereal Chem. 55:383.
- Shen, J.L. 1976. Soy protein solubility: The effect of experimental conditions on the solubility of soy protein isolates. Cereal Chem. 53:902.
- Sipos, E.F., Turro, E. and Williams, L.D. 1974. Soy protein products for baked goods. Baker's Dig. 48(2):29.
- Smith, A. 1958. Vegetable protein isolates. In: Processed Plant Protein Foodstuffs. A. Altschul (Ed.). Academic Press Inc., New York, NY.
- Smith, A.K. and Circle, S.J. 1972. Soybeans: Chemistry and Technology. AVI Publishing Company, Inc., Westport, CT.
- Tanford, C. 1963. Physical Chemistry of Macromolecules. John Wiley & Sons, New York, NY.
- Tsen, C.C. and Tang, R.T. 1971. K-State process for making high-protein breads. I. Soy flour bread. Baker's Dig. 45(5):26.
- Tsen, C.C. and Hoover, W.J. 1973. High-protein bread from wheat flour fortified with full fat soy flour. Cereal Chem. 50:7.
- Wolf, W.J. 1969. Chemical and physical properties of soybean proteins. Baker's Dig. 43(5):30.

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Functionality of Soy Proteins in Wheat Flour/Soy Isolate Doughs.

II. Rheological Properties and Bread Making Potential

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Abstract

The dough and baking performance of wheat flour supplemented with soy protein isolates prepared under different conditions of extraction, precipitation and drying was evaluated in an attempt to relate it to the physical and physico-chemical properties of the supplementing material. Expectedly, the isolates differed most in their hydration capacity and solubility (dispersibility), but there was an ambiguity in the relationship of these properties to the baking performance, displayed most noticeably in the loaf volume depression effect. The involvement of a mechanism other than hydration (e.g., complexing effect of polyvalent calcium, the presence of reactive SH and SS groups) was best demonstrated by the comparison of the isoelectric protein and Ca proteinate. While they both were characterized by a very low hydration and solubility, they were found among the test isolates to exhibit the highest and lowest loaf depressing effect, respectively. Rheological tests (farinography, amylography, extensigraphy), performed on supplemented flour or dough, provided a closer assessment of the suitability of the supplement for bread making. The ranking of the isolates in this respect was not changed by the addition of any surfactant used in the study.

Résumé

Des isolats de protéine de soja préparés sous différentes conditions d'extraction, de précipitation et de séchage furent ajoutés à de la farine de blé pour étudier l'effet de leurs propriétés physiques et physico-chimiques sur les caractéristiques de la pâte et sur l'aptitude à la cuisson. Comme on s'y attendait, les isolats étaient très différents aux plans du pouvoir d'absorption d'eau et de la solubilité (dispersibilité), mais le rapport de ces propriétés à l'aptitude à la cuisson est apparu plutôt indéfini particulièrement en ce qui a trait à l'effet d'affaissement de volume du pain. L'implication d'un mécanisme différent de l'hydratation (e.g., la formation de complexes par les ions polyvalents du calcium, la présence de groupements réactifs SH et SS) a bien été démontrée par la comparaison de la protéine isoélectrique au protéinate de calcium. Bien que l'une et l'autre aient un très faible pouvoir d'hydratation et une très faible solubilité, ce sont les isolats qui ont démontré respectivement le

plus fort et le plus faible effet d'affaissement du pain. C'est par des tests rhéologiques (farinographie, amylographie, extensigraphie) sur la farine ou sur la pâte que l'on a pu mieux évaluer l'aptitude de ces additifs en boulangerie. L'addition d'agents tensio-actifs n'a pas changé l'ordre des isolats sous ce rapport.

Introduction

It is well recognized that the success of a protein supplement in a protein fortified bread formula will depend not only on its inherited nature but the type of treatment it has received during its preparation (Pollock and Geddes, 1960a,b; Finney *et al.*, 1963; Paulsen and Horan, 1965; Mizrahi *et al.*, 1967; Rooney *et al.*, 1972; Yasamatsu *et al.*, 1972; Ranhotra *et al.*, 1974; Betschart *et al.*, 1975; Fleming and Sosulski, 1977; Khan and Lawhon, 1980). In an attempt to elucidate in more detail the relationship between the isolation treatment and the functional behaviour of soy protein, isolates were prepared under different conditions of extraction (water and alkali extraction), treatment of extracted proteins (isoelectric precipitation and neutralization to form Ca, K and Na proteinates), and drying (freeze-, spray and drum drying). Work discussed in this paper was focused on the evaluation of these isolates with respect to their effects on the rheological and bread baking quality of blends prepared from the test material and bread-wheat flour. The objective was to relate the bread baking quality of the isolates to their chemical and physico-chemical properties, which were quantitatively evaluated in Part I (Chen and Rasper, 1982), and to search for testing criteria which could be used for a quantitative assessment of the suitability of the supplementing protein for the given purpose. At the same time, the response of the test isolates to the presence of a surfactant in the blend was also a subject of the study. Surfactants, very often referred to as surface active dough

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conditioners, have been extensively used to overcome the impairing effect of protein supplements on the volume and texture of protein enriched breads. Their application and mechanism of their action were comprehensively discussed in numerous publications (Pomeranz *et al.*, 1969a,b; Tsen *et al.*, 1971; Fleming and Sosulski, 1974; Pomeranz and Chung, 1978; Chung *et al.*, 1981).

Materials and Methods

Wheat Flour/Soy Isolate Blends

All blends were prepared by replacing 8% dry solids of commercially milled bread-wheat flour (12.8% protein, 61.6% farinograph absorption, both on 14% moisture basis) with an equal part of soy isolate dry solids. The preparation of the isolate was described earlier (Chen and Rasper, 1982). Surfactants used in the study included anionic sodium stearyl-2-lactylate (SSL), nonionic hydrophilic polysorbate 60 (Tween 60) and nonionic lipophilic sodium tristearate (Span 65). The first one was supplied by Semmons-Taylor Co. Ltd., Montreal, Que.; the other two were products of Atlas Chemical Industries Canada Ltd., Brantford, Ont. All surfactants were added in solid form (1%, flour basis) to wheat or wheat flour/soy isolate mixture prior to the addition of water to form dough.

Pasting Characteristics

All flours (both wheat flour control and wheat flour/soy isolate blends) were pasted as 16.3% (w/v) slurry (dry solids basis) using a Brabender ViscoAmylograph. A bowl speed of 75 rpm, a sensitivity cartridge of 350 cmgf and a heating or cooling rate of 1.5°C/min were employed as operating conditions for pasting evaluation. The slurries were heated from 30–95°C, held at 95°C for 30 min, then cooled to 50°C, and held at this temperature for an additional 30 min.

Dough Mixing Characteristics

Farinograph absorption and farinograph mixing parameters were obtained according to constant flour weight farinograph AACC (1969) Method 54-21 using a 50 g stainless steel mixing bowl and fast speed mixing.

Tensile Strength (Stretchability) Tests

Doughs were prepared by mixing wheat flour or test blends to optimum development consistency (500 BU) in a 50 g stainless steel farinograph mixing bowl at 30 ± 1°C. The amount of water taken was equal to farinograph absorption of each mixture less 1.5% to compensate for the effect of NaCl added (0.75%, flour basis). Each dough was divided into two pieces of approximately 40 g. After rounding and resting for 45 min in a humidified container, the dough balls were sheeted to uniform thickness and two rings were cut out from each sheet (Rasper *et al.*, 1974). After 45 min resting, the rings were stretched in a simple tensile mode using an Instron Universal Testing Machine with a special crosshead attachment (Rasper, 1975). Resistance to extension was expressed as force required to stretch the dough ring to the length of 7.5 cm at crosshead speed of 50 cm x min⁻¹ (extension rate 0.22 s⁻¹).

In stress relaxation studies, the dough rings were stretched at the same extension rate as above to reach

deformation of 0.8 cm. They were allowed to relax and the decay of the tensile strength was recorded. Relaxation time was defined as the time required for 36.7% relaxation of the maximum load at the beginning of the relaxation period (deMan, 1976).

Baking Performance

Test loaves were baked according to the straight dough AACC (1969) Method 10-10. The doughs were mixed to optimum development consistency in a Brabender Farinograph (300 g stainless steel mixing bowl, 30 ± 1°C). The fermentation and proofing times for supplemented doughs were decreased and increased, respectively, in order to get optimum performance, but they were maintained the same for all test blends. The dough handling procedure was modified for 60 g dough pieces. The first setting on sheeting rolls for punching was 5/32", the second was 3/16". The loaves were baked for 15 min at 220°C in baking tins with the following dimensions: 8.5 x 4.6 cm at the top, 7.0 x 3.2 cm at the bottom and 3.5 cm in height. Specific volumes of loaves were determined by rapeseed displacement 2 h after baking.

Crumb Compressibility and Firming Rate

The crumb compressibility was measured with a Precision Penetrometer using a circular punch (1 cm in diameter) and 50 g weight. The compression after 5 s penetration into a 1" slice of test crumb was expressed in 1/10 mm. The first measurement was taken 12 h after baking, and the measurements were repeated for 3 consecutive days during which the samples were kept in polyethylene bags at 20°C.

Crust Colour

A 1.0 square inch of crust was cut out from the top of the test loaf and the colour was measured with a Hunter Colour Difference Meter (Hunter Lab D25D) with pink standard (L = 73.8, a = 11.2 and b = 6.8). The total colour difference between the control and each sample was expressed as $E = \sqrt{(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2}$. Two measurements were performed with each loaf.

Crumb Grain Score

Crumb grain score was based on the ranking evaluation by six panelists using a 1-10 score, with ten being the best score.

Results and Discussion

As expected, blending of the isolates with wheat flour resulted in markedly higher farinograph absorptions compared to the control value of the plain wheat flour (Table 1). The dependence of this increase on the type of isolate with respect to the extraction medium used in its preparation became evident. Absorption values of blends supplemented with alkali extracted protein exceeded by approximately 1% those obtained for blends containing the water extracted material. Precipitation technique also appeared to be a factor. The highest absorption values were measured with blends supplemented with Ca proteinates, whereas values for all other mixtures were found to be in a relatively narrow range.

Ambiguity was observed in the relationship between the measured data for supplemented blends and the hydration capacity of the supplementing isolates which

Table 1. Farinograph absorptions of wheat flour/soy protein isolate mixtures (8% supplementation on dry solids basis) in the absence and presence of surfactant (1% on flour basis).

Type of isolate in mixture	Farinograph absorption (%)								
	Surfactant								
	None		SSL		Tween 60		Span 65		Mean
None ¹	61.6	(0.3)	61.9	(0.4)	60.9	(0.2)	62.8	(0.7)	
Water extracted isolates: ²									
Isoelectric protein	63.6ab	(0.6) ³	64.4	(0.1)	62.7a	(0.3)	64.1ab	(0.1)	63.7ab
Ca proteinate	65.9c	(0.2)	66.8c	(0.3)	65.6	(0.3)	66.3c	(0.2)	66.2
K proteinate	63.4a	(0.5)	64.6a	(0.1)	62.4a	(0.5)	63.7a	(0.6)	63.5a
Na proteinate	64.0bd	(0.3)	65.1b	(0.2)	63.2ab	(0.2)	64.2ab	(0.4)	64.1b
Mean	64.2		65.2		63.5		64.6		
Alkali extracted isolates: ²									
Isoelectric protein	64.4d	(0.5)	65.4b	(0.1)	63.3ab	(0.3)	64.7b	(0.3)	64.4
Ca proteinate	66.9	(0.2)	67.9	(0.2)	66.3b	(0.5)	67.3	(0.2)	67.1c
K proteinate	64.4d	(0.3)	66.0c	(0.2)	63.5b	(0.4)	64.7b	(0.2)	64.6b
Na proteinate	65.5c	(0.3)	66.5c	(0.2)	64.1	(0.1)	65.6	(0.4)	65.4c
Mean	65.3		66.5		64.3		65.6		
Na proteinate (spray dried)	64.5d	(0.4)	65.6b	(0.5)	63.4ab	(0.2)	64.6b	(0.2)	64.6b
Na proteinate (drum dried)	65.8cd	(0.1)	65.6bc	(0.3)	64.7	(0.2)	66.0c	(0.2)	65.5

¹Control data not included in statistical analysis.

²Freeze-dried isolates, unless otherwise stated.

³All data are means (standard deviation) based on four replicates. Data in vertical columns not followed by the same letter are significantly different ($P < 0.05$) using Duncan's multiple range test.

was discussed in Part I (Chen and Rasper, 1982). While higher farinograph absorptions of blends supplemented with alkali extracted protein were in agreement with higher hydration capacity of the corresponding isolates, high farinograph absorption of Ca proteinate supplemented doughs contrasted with both very low water absorption and water retention capacities of this particular isolate. Since these two capacities correlated very closely with the solubility of the isolates, neither of these three properties appeared to be closely related to the water requirements of the supplemented test dough. Similar results were reported by Ranhotra *et al.* (1974). The indirect approach to the estimation of water absorption by using the farinograph test may offer an explanation for this discrepancy. The test gives results dependent not only on the actual absorption capacity, but also on the rheological nature of the test material. The separation of these two contributions towards the final result is practically impossible. Thus, any change in the rheological character of the tested system due to any interactions caused by the supplementing material will inevitably be reflected in the measured value. Such observations were also made in studying the effect of components other than protein on the water absorptive capacity of composite flour blends (Rasper and deMan, 1980). In the case of Ca proteinate supplemented mixture, one may speculate on changes in consistency of the dough due to some soy protein gluten or starch-starch interactions due to the presence of a polyvalent cation. The discrepancy between the hydration capacity of the supplementing protein and farinograph absorption of the supplemented mixture also appeared in the evaluation of the results of tests with Na proteinates which received different drying treatment. In spite of a

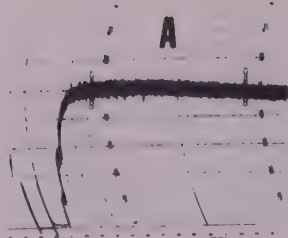
marked difference between the hydration capacity of the drum dried and other two proteinates, there was little difference between the farinograph absorptions of the respective mixtures. Results of a similar study on wheat protein concentrates (Betschart *et al.*, 1975), in which acid and heat precipitated concentrates were freeze-, spray or drum dried, revealed enhanced farinograph absorption of concentrate/flour mixtures, but no consistent trend emerged in comparing the effect of drying technique.

The pattern showing the effect of the individual isolates on the discussed property of the test blends did not change after the addition of any of the three surfactants. The addition of SSL, regardless of the type of isolate present in the blend, led to absorption values distinctly higher than those measured for mixtures without any surfactant (average increase for doughs supplemented with freeze-dried isolate was 1.1%). On the other hand, values consistently below the control were obtained with doughs containing Tween 60 (an average decrease of 0.85%). Span 65 did not cause any substantial change in the evaluated property when added to the supplemented mixture.

Rheological Characteristics of Supplemented Doughs

As indicated by farinograms shown in Figure 1a, blends supplemented with Ca proteinate or alkali metal (K, Na) proteinates displayed a tendency to yield double peak farinograph curves. No such tendency was detected from curves of mixtures containing isoelectric protein. Double peak curves are usually obtained with low gluten wheat flours due to a rapid absorption of water and a slower development of gluten (Tanaka and Tipples, 1969).

1a



1b

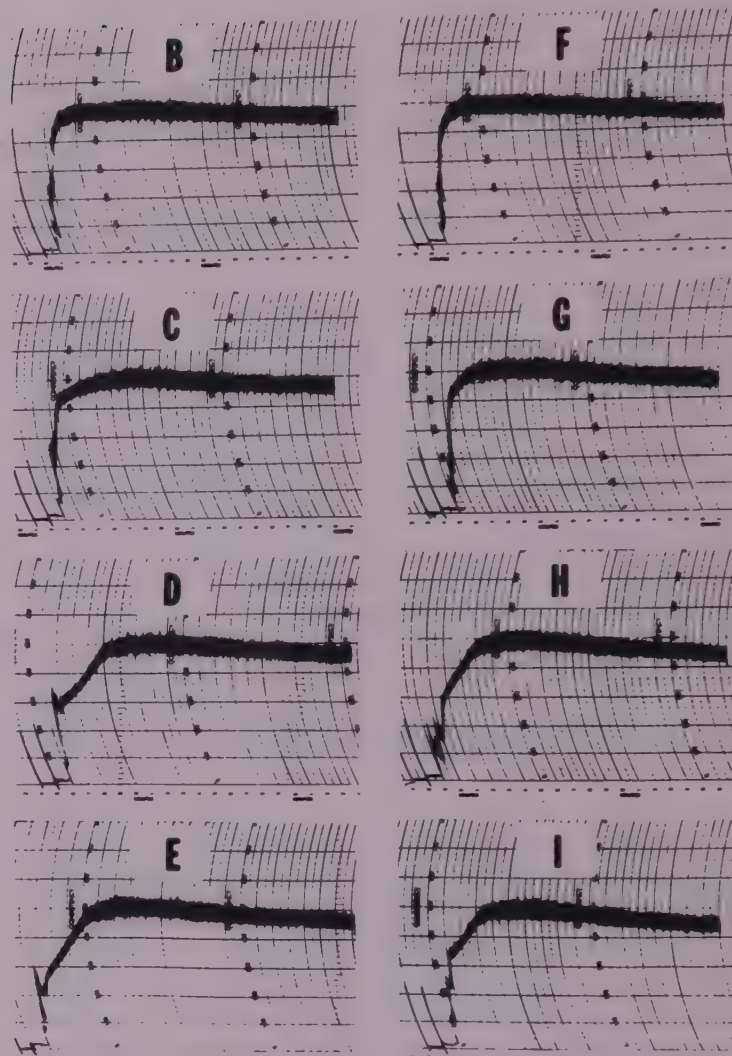
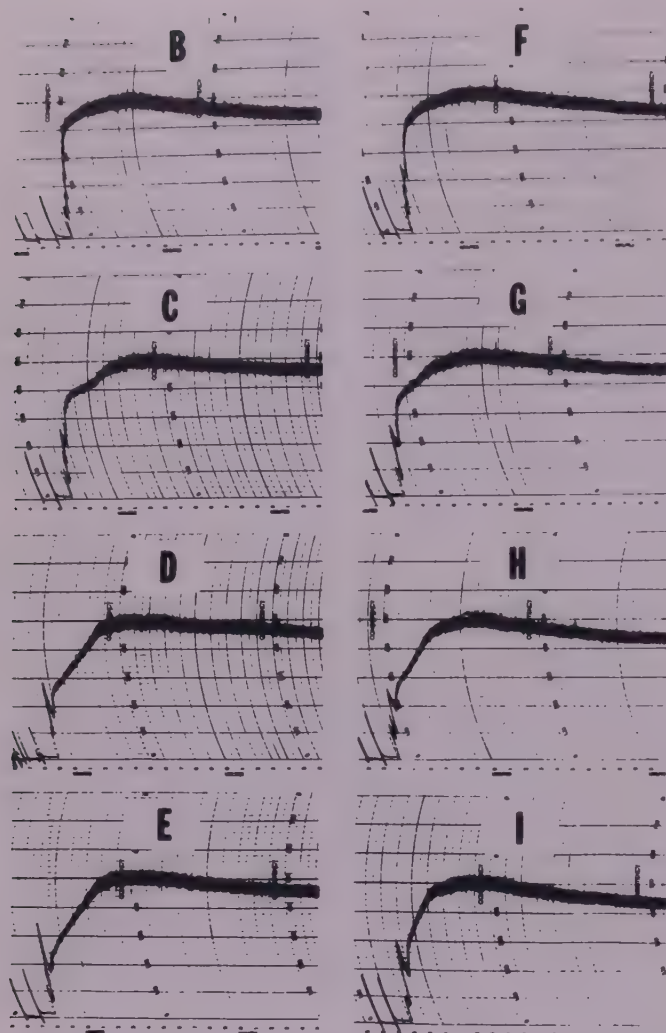
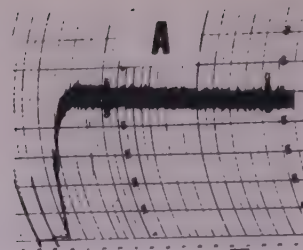


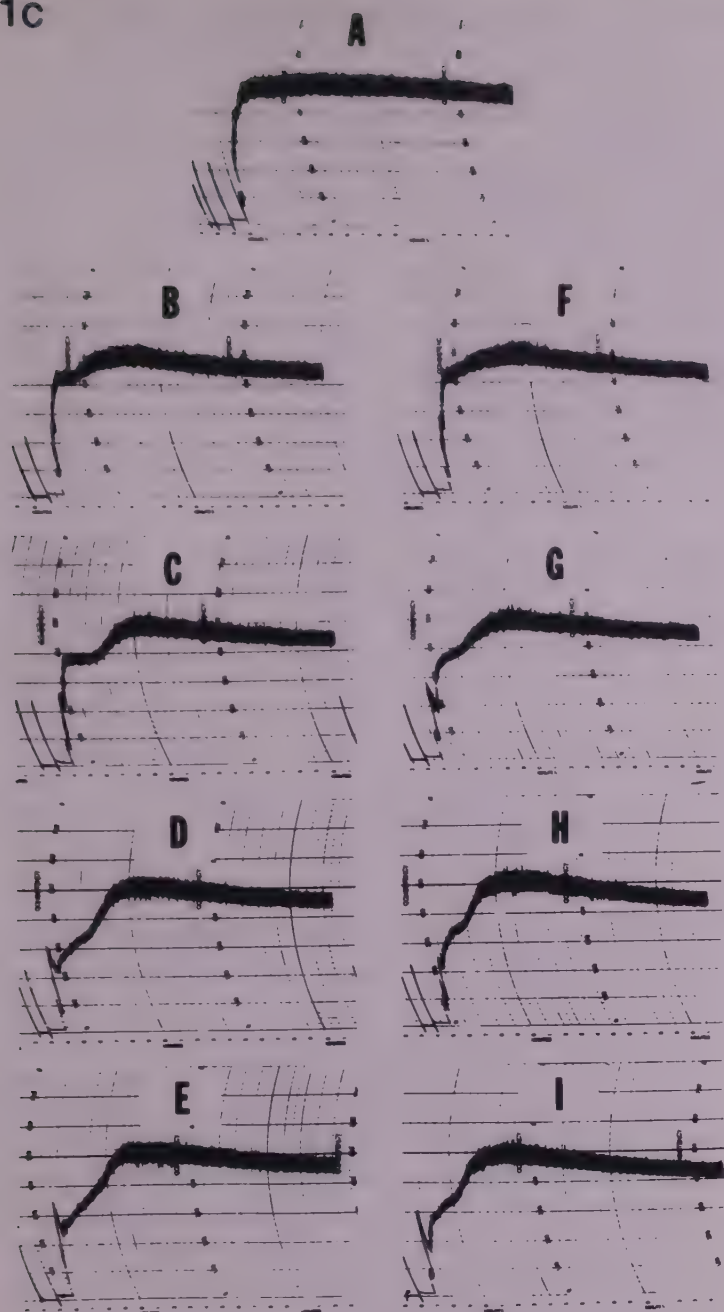
Fig. 1. Farinograph curves of wheat flour/soy protein isolate blends (8% supplementation level) in the absence or presence of surfactant (1%, flour basis). 1a – No surfactant; 1b – SSL; 1c – Tween 60; 1d – Span 65. Type of isolate in the blend: water extracted, B – isoelectric protein; C – Ca proteinate; D – Na proteinate; E – K proteinate; alkali extracted, F – isoelectric protein; G – Ca proteinate; H – Na proteinate; I – K proteinate; A – wheat flour control.

Double peak farinograph curves were earlier reported for mixtures of wheat flour and pea protein concentrate (Townsend, 1977) and mixtures of wheat flour and soy protein concentrate or isolate (Onayemi and Lorenz, 1978). From analogy with low gluten wheat flours, the phenomenon of double peaking might be attributed to the difference in the hydration rate of the two principal components in the mixture (i.e., wheat flour and supplementing material). However, in evaluating the farinograph performance of the blends used in the present study, no consistency was found in the relationship between the shape of the farinograms at the dough development stage and the hydration capacity of the individual supplementing isolates. Though calcium and monovalent ion proteinates distinctly differed with respect to this capacity, they all yielded double peak curves. The formation of double peaks appeared to be affected by the

presence of surfactant in the blend. It practically disappeared from the farinograms of doughs supplemented with Ca proteinate in the presence of the anionic SSL (Figure 1b). On the other hand, nonionic hydrophilic Tween 60 and lipophilic Span 65 enhanced the formation of the second peak; in the presence of the former, two peaks appeared even on the farinograms of doughs supplemented with isoelectric protein (Figure 1c,d).

The differences between the test isolates were also reflected in some of the data obtained from the farinograph curves. While the addition of isoelectric protein to wheat flour increased the arrival time by not more than 1.5 min, mixtures supplemented with proteinates were all characterized by arrival times 2-5 min longer. Usually, changes in arrival time of composite blends are related to water absorption of the supplementing material (Onayemi and Lorenz, 1978). Observed differences in arrival time,

1c



1d

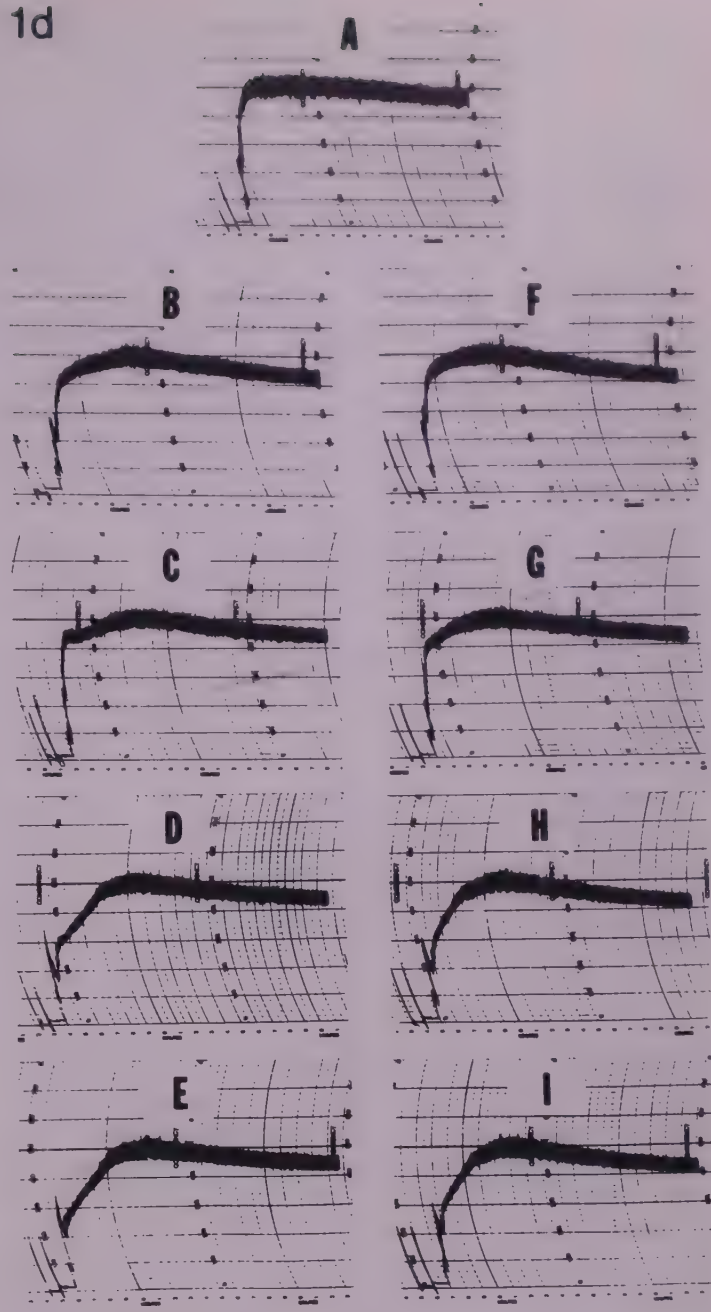


Fig. 1. Farinograph curves of wheat flour/soy protein isolate blends (8% supplementation level) in the absence or presence of surfactant (1%, flour basis). 1a - No surfactant; 1b - SSL; 1c - Tween 60; 1d - Span 65. Type of isolate in the blend: water extracted, B - isoelectric protein; C - Ca proteinate; D - Na proteinate; E - K proteinate; alkali extracted, F - isoelectric protein; G - Ca proteinate; H - Na proteinate; I - K proteinate; A - wheat flour control.

despite a great similarity in the hydration capacity of isoelectric protein and Ca proteinate, support the suggestion that a mechanism other than hydration was involved in the apparent "strengthening" of the dough in the presence of divalent ion. Ca proteinate exhibited also the most promising effect on the stability of the dough. In this respect, it resembled the drum dried Na proteinate. The stability of the doughs seemed also to be affected by the type of extraction medium used in the preparation of the isolates, as shown by a distinctly higher degree of softening in the presence of the alkali extracted isolates compared to the water extracted ones. The mixing stability of supplemented doughs was improved by the addition of SSL to an extent that it almost equalled that of the control dough. On the other hand, with Tween 60 or Span 65 present in the dough, the more pronounced softening effect of alkali extracted proteinates was still clearly detectable.

The differences in the behaviour of the test isolates were further evidenced by the results of stretchability tests (Table 2). There was an expected overall increase in the resistance to extension caused by all test materials, but the magnitude of this increase varied according to the type of the isolate. In the presence of alkali extracted isolates, the increase exceeded that caused by the water extracted ones by approximately 25%. Isoelectric protein caused a much higher rise in this property than any of the isolates precipitated in the form of proteinate. Among those, Ca proteinate gave the lowest values. While both freeze- and spray dried proteinates made the dough more resistant without showing any significant difference between these two treatments, drum dried proteinate left the stretching properties of the dough practically unaffected.

In comparing the stretchability data with farinograph absorptions, a negative correlation appeared between the

Table 2. Resistance to extension of doughs prepared from wheat flour/soy protein isolate mixtures (8% supplementation on dry solids basis) in the absence and presence of surfactant (1% on flour basis).

Type of isolate in mixture	Resistance to extension (gf) ¹								Mean
	Surfactant								
	None		SSL		Tween 60		Span 65		
None ²	10.8	(0.7)	9.5	(0.4)	10.0	(0.6)	9.0	(0.4)	9.8
Water extracted isolates: ³									
Isoelectric protein	22.2	(0.9) ⁴	20.2	(0.5)	22.7a	(1.1)	20.1	(0.8)	21.3b
Ca proteinate	14.3	(0.6)	13.2	(0.2)	12.3	(0.7)	13.8	(0.3)	13.4
K proteinate	16.5	(0.4)	15.0a	(0.4)	15.1	(0.6)	17.0	(0.2)	15.1
Na proteinate	18.8	(0.4)	15.7a	(0.7)	17.4b	(0.3)	15.3a	(0.5)	16.8a
Mean	18.8		16.0		16.9		16.6		
Alkali extracted isolates: ³									
Isoelectric protein	24.0	(0.8)	21.7b	(0.4)	26.5	(1.3)	27.5	(0.5)	24.9
Ca proteinate	17.8	(0.6)	15.4a	(0.2)	16.4b	(0.5)	15.6a	(0.1)	16.3a
K proteinate	19.4	(0.6)	19.1	(0.7)	23.1	(0.4)	22.7	(0.5)	21.2b
Na proteinate	20.9	(0.4)	21.0b	(0.6)	21.8a	(1.0)	21.1	(0.2)	21.2
Mean	20.5		19.3		21.9		21.7		
Na proteinate (spray dried)	17.7	(0.3)	20.1a	(0.8)	21.8a	(0.5)	17.4	(0.3)	19.2
Na proteinate (drum dried)	10.3	(0.3)	13.1	(0.5)	14.2	(0.7)	11.6	(0.4)	12.3

¹Measured at 7.5 cm extension in gram force.
²Control data not included in statistical analysis.
³Freeze-dried isolates, unless otherwise stated.
⁴All data are means (standard deviation) based on four replicates. Data in vertical columns not followed by the same letter are significantly different (P<0.05) using Duncan's multiple range test.

changes in the resistance to extension caused by the added isolate and the adjustments in the amount of water required to obtain dough of standard farinograph consistency (500 BU). This observation could easily lead to a conclusion that the differences in the tensile properties of the tested doughs should be primarily related to changes in the free and bound water conditions in the system, which are recognized as factors controlling the mobility of the dough. Although this may be true with most of the test doughs, the results with alkali extracted Na proteinates indicate that some other mechanism affecting the rheologically active components was also involved. The mentioned proteinates differed in their resistance to extension in spite of a relatively narrow range of their farinograph absorptions. Changes in the viscoelastic properties of wheat dough are generally attributed to sulphydryl disulphide interchanges with possible involvement of the lipoxigenase (Faubion and Hoseney, 1981). The lipoxigenase linoleate system can be considered an improver in dough (Daniels *et al.*, 1974; Hoseney *et al.*, 1980; Kieffer and Grosch, 1980). Frazier *et al.* (1977) observed an increase in the relaxation time of wheat dough with added soy lipoxigenase. A relatively short relaxation time measured with drum dried proteinate supplemented dough (Table 3) could be taken as an evidence for lacking improving effect due to the thermal inactivation of the enzyme. It would be an oversimplification to relate this phenomenon to only one factor. It may be also noted that the drum dried proteinate had the lowest content of reactive SH and disulphide groups among the test isolates (Chen and Rasper, 1982).

The interpretation of all these rheological data has to

be done with a great deal of caution. Dough does not strictly follow the Maxwellian model and, therefore, any characterization of its stress relaxation process by only one value of relaxation, instead of the whole relaxation time spectrum, may lead to erroneous results. The data may serve as supporting evidence for the variability in the rheological behaviour of the test material, but they should be considered of only relative value. Increased resistance of dough to extension is usually taken as a sign of a higher "flour strength" due to the enhancement of its elastic response. Tested supplemented doughs did not show any sign of such changes; their higher resistance to extension would be more appropriately interpreted as a sign of greater stiffness or plasticity.

Pasting Characteristics

At the given sensitivity of the instrument and concentration of the slurry, none of the test isolates gave any measurable viscosity response when used without wheat flour. Contrary to results of Onayemi and Lorenz (1978), they all reduced the hot paste peak viscosity of wheat flour when used at 8% supplementation level, with the extent of this reduction being dependent on the type of isolate (Figure 2). Isoelectric protein caused the highest reduction (69% and 65% for isolate extracted with water and alkali, respectively), while values closest to the control were recorded with Ca proteinate/wheat flour mixtures (respective values of hot paste viscosity reduction over the control for water and alkali extracted Ca proteinate were 17% and 21%). The difference in the effect of the extraction medium was not as manifest to establish any relationship. Like hot paste viscosity, the

Table 3. Relaxation times of doughs prepared from mixtures of wheat flour and tested isolates (8% supplementation on dry solids basis) in the absence and presence of surfactant (1% on flour basis).

Type of isolate in mixture	Relaxation time (s)				Mean
	Surfactant				
	None	SSL	Tween 60	Span 65	
None	2.7 ¹	2.1	2.5	3.1	2.6
Water extracted isolates: ²					
Isoelectric protein	7.8 ¹	6.3	8.1	9.1	7.8
Ca proteinate	4.6	5.0	5.6	5.8	5.2
K proteinate	3.8	4.7	4.2	5.2	4.5
Na proteinate	5.1	5.2	5.0	5.7	5.2
Alkali extracted isolates: ²					
Isoelectric protein	6.1	6.2	6.8	7.4	6.6
Ca proteinate	6.1	5.5	5.4	5.6	5.7
K proteinate	5.1	5.4	5.7	5.8	5.5
Na proteinate	4.7	5.9	6.4	6.3	6.6
Na proteinate (spray dried)	5.0	6.1	5.4	5.1	5.4
Na proteinate (drum dried)	2.3	2.3	2.3	2.2	2.3

¹All data are based on quadruplicate determinations.

²Freeze-dried isolates, unless otherwise stated.

gelling properties also varied with the type of isolate. In the presence of isoelectric protein, only a marginal viscosity increase was recorded upon cooling the hot paste to 50°C, but a markedly steep rise in viscosity resulted from the presence of Ca proteinate in the mixture. Low viscosities recorded with isoelectric protein throughout the whole pasting cycle may be partially attributed to a low pH (pH 4.9) of this isolate, which may have resulted in a measurable hydrolytic effect upon flour starch. On the other hand, higher viscosities measured with the Ca proteinate may be attributed to its limited hydration capacity, which kept the competition for water between the gelatinizing starch and supplementing protein at a minimum. The calcium starch complexing effect should also be considered (Hood and O'Shea, 1977). Lower competition for water may also explain the highest viscosities measured during the cooling (gelling) stage with drum dried Na proteinate. It may be noticed that its amylographic data, during this stage of the pasting cycle, closely resembled those of the wheat flour control.

Baking Performance

As expected, all isolates exhibited a loaf volume depressing effect. The extent of this effect was in most cases related to the nature and behaviour of the isolates and supplemented doughs as revealed in the above discussed tests (Table 4). In the absence of any surfactant, the alkali extracted freeze-dried isolates gave rise to loaves showing a loaf volume depressing effect on average 16% higher than that measured with breads supplemented with the water extracted isolates. Within each of these two types, Ca proteinates depressed the loaf volume to the least degree, whereas the most detrimental effect could be seen with the isoelectric protein. These findings were in contrast with some earlier literature data

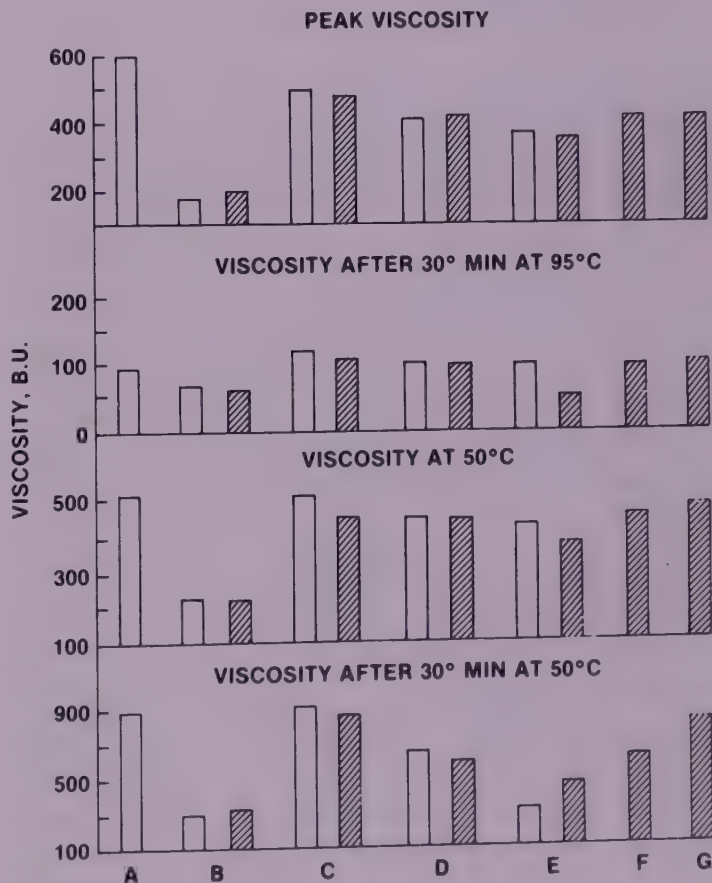


Fig. 2. ViscoAmylograph characteristics of wheat flour/soy protein isolate blends (8% supplementation level). A – wheat flour control; B – wheat flour + isoelectric protein, freeze-dried; C – wheat flour + Ca proteinate, freeze-dried; D – wheat flour + K proteinate, freeze-dried; E – wheat flour + Na proteinate, freeze-dried; F – wheat flour + Na proteinate, spray dried; G – wheat flour + Na proteinate, drum dried. □ Water extracted isolates. ▨ Alkali extracted isolates.

Table 4. Changes in specific loaf volume due to supplementation of wheat flour with tested isolates (8% supplementation level) in the absence and presence of surfactant (1% on flour basis).

Type of isolate in mixture	Reduction in specific loaf volume ¹ (%)				Mean
	Surfactant				
	None	SSL	Tween 60	Span 65	
Specific volume of control loaf (mL/g)	(4.45)	(5.27)	(5.10)	(4.52)	
Water extracted isolates: ²					
Isoelectric protein	-24.5 ³	-36.6	-14.1	-22.3	-24.3
Ca proteinate	-13.3	-11.4	-10.2	-13.2	-12.0
K proteinate	-19.8	-19.2	- 9.6	-22.1	-17.7
Na proteinate	-15.7	-18.4	- 7.6	-22.8	-16.1
Mean	-18.3	-21.4	-10.4	-20.1	
Alkali extracted isolates: ²					
Isoelectric protein	-37.1	-44.8	-31.4	-36.7	-37.5
Ca proteinate	-24.0	-29.3	-22.6	-29.0	-26.2
K proteinate	-34.2	-36.1	-29.2	-33.4	-33.2
Na proteinate	-34.8	-39.5	-31.4	-34.7	-33.5
Mean	-32.5	-37.4	-28.7	-33.5	
Na proteinate (spray dried)	-35.5	-36.4	-29.6	-33.4	-33.7
Na proteinate (drum dried)	-15.1	-11.1	-10.4	-17.3	-13.5

¹Reduction expressed as percentage of the specific volume of the control loaf of the respective unsupplemented bread (without any isolate added).

²Freeze-dried isolates, unless otherwise stated.

³All data are based on triplicate determinations.

(Sipos *et al.*, 1974), which showed a lower loaf volume depressing effect in the presence of both isoelectric protein and calcium forms than in the presence of the monovalent salt protein. With the isolates used in this study, the degree of loaf depression was not found to be unambiguously related to those properties of the isolates in which they differed most pronouncedly – hydration capacity and solubility. On the other hand, there was a good correlation between the loaf volume data and results of some rheological tests performed on the supplemented doughs. Correlation coefficients of -0.765 ($P<0.05$) and -0.936 ($P<0.01$) were computed for the relationship between extensigraph resistance and loaf volume for samples supplemented with water and alkali extracted isolates, respectively (all freeze-dried). High correlation was also found between loaf volume and farinograph absorption (0.908 ($P<0.01$) and 0.827 ($P<0.01$) for the same respective isolates).

There was, however, no consistent trend shown by the precipitated proteins on crumb grain scores and crust colour (Table 5). The only difference was noticed when average grain scores for breads supplemented with either water extracted or alkali extracted isolates were compared. The former gave more favourable results. A less impairing effect on the bread making quality of water extracted isolates, as compared with the alkali extracted ones, was also evidenced by lower firming rates for breads baked from mixtures containing the water extracted protein (Figure 3).

The ranking of the isolates as to their loaf depressing action remained practically unchanged in the presence of any of the three surfactants. The most pronounced im-

proving effect was observed with SSL doughs. This statement may seem to be in disagreement with the relatively high values of loaf volume reduction (%) shown in Table 4, but since these values were calculated as a percentage of the SSL control which gave the highest

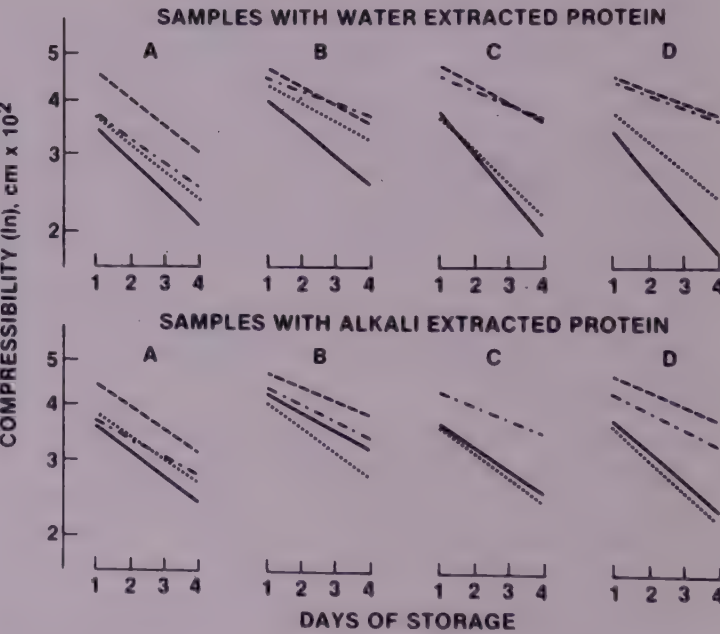


Fig. 3. Firming of breads baked from wheat flour/soy protein isolate blends (8% supplementation level) in the absence or presence of surfactant (1% on flour basis). Type of isolate in the blend: A – isoelectric protein, freeze-dried; B – Ca proteinate, freeze-dried; C – Na proteinate, freeze-dried; D – K proteinate, freeze-dried. Type of surfactant: — none; - - - - - SSL; Tween 60; - Span 65.

Table 5. Crumb grain scores and crust colour of breads baked from mixtures of wheat flour and tested isolates (8% supplementation on dry solids basis) in the presence and absence of surfactant (1% on flour basis).

Type of isolate in mixture	Crumb grain				Crust colour			
	Surfactant							
	None	SSL	Tween 60	Span 65	None	SSL	Tween 60	Span 65
None	8	9	9	8	0.00	1.04	0.52	0.20
Water extracted isolates: ¹								
Isoelectric protein	5	6	9	3	0.60	0.33	0.59	0.53
Ca proteinate	7	8	10	7	0.42	0.00	0.93	0.28
K proteinate	5	8	8	6	0.56	0.19	0.71	0.69
Na proteinate	7	8	10	6	0.80	0.51	0.86	0.56
Mean	6	7.5	9.3	5.5	0.60	0.26	0.77	0.52
Alkali extracted isolates: ¹								
Isoelectric protein	4	5	8	2	0.63	1.65	0.64	0.52
Ca proteinate	6	8	9	6	0.59	0.29	0.31	0.16
K proteinate	4	6	7	5	1.05	0.51	0.81	0.78
Na proteinate	4	5	7	5	0.16	0.58	0.60	0.45
Mean	4.5	6	7.8	4.5	0.61	0.78	0.59	0.48
Na proteinate (spray dried)	2	5	6	4	0.70	0.29	0.93	1.09
Na proteinate (drum dried)	6	8	8	7	0.29	0.67	0.33	0.59

¹Freeze-dried isolates, unless otherwise stated.

specific loaf volume (5.3 mL/g) among all tested loaves, the supplemented SSL breads were still found to be the largest ones. The relatively low depression data for Tween 60 agreed with the results of Fleming and Sosulski (1977), who used this surfactant in soy protein concentrate supplemented doughs. The actual loaf volume values of Tween 60 breads, however, did not reach those of SSL breads. The improving effect of Span 65 on both loaf volume and crumb compressibility was relatively small. In combination with alkali extracted protein, this surfactant had even an adverse effect on the latter.

Conclusion

In summary, the applied tests revealed the effects of both extraction medium and the type of treatment used in the preparation of the isolates on their functionality in the studied system. The most critical assessment was made during the baking tests, in which the most obvious effect was the loaf depressing action, whereas the others were relatively minor compared to that. In relating the results of the baking tests to those performed on the individual isolates, the complexity of the nature and action of the supplementing material became evident. Very often the suitability of a supplement for bakery products is judged solely on the basis of its solubility (dispersibility). As best demonstrated by the comparison of the freeze-dried isoelectric protein and Ca proteinate used in the study, this single criterion may not always give a satisfactory prediction of the baking performance if a supplement of varying nature is considered. A closer assessment of the baking quality of the individual isolates, based on their properties, was achieved by testing their behaviour in actual wheat flour/soy protein mixtures using dough rheology tests.

Acknowledgements

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References

- AACC. 1969. Approved Methods. American Association of Cereal Chemists, St. Paul, MN.
- Betschart, A.A., Saunders, R.M. and Kohler, G.O. 1975. Effects of processing on the baking quality of wet alkaline process wheat protein concentrate. *Cereal Chem.* 52:812.
- Chen, S.S. and Rasper, V.F. 1982. Functionality of soy proteins in wheat flour/soy isolate doughs. I. Characterization of isolates prepared using different isolation procedures. *Can. Inst. Food Sci. Technol. J.* 15:203.
- Chung, O.K., Tsen, C.C. and Robinson, R.J. 1981. Functional properties of surfactants in breadbaking. III. Effects of surfactants and soy flour on lipid binding in breads. *Cereal Chem.* 58:220.
- Daniels, N.W.R., Frazier, P.J. and Wood, P.S. 1974. Flour lipids and dough development. *Baker's Dig.* 45(4):20.
- deMan, J.M. 1976. Mechanical properties of foods. In: *Rheology and Texture in Food Quality*. J.M. deMan, P.W. Voisey, V.F. Rasper and D.W. Stanley (Eds.). AVI Publishing Company, Inc., Westport, CT.
- Faubion, J.M. and Hoseney, R.C. 1981. Lipxygenase: Its biochemistry and role in breadmaking. *Cereal Chem.* 58:175.
- Finney, K.F., Rubenthaler, G. and Pomeranz, Y. 1963. Soy-products variables affecting bread baking. *Cereal Sci. Today* 8:166.
- Fleming, S.E. and Sosulski, F.W. 1974. Dough conditioners in wheat-soy-gluten breads. *Can. Inst. Food Sci. Technol. J.* 7:51.
- Fleming, S.E. and Sosulski, F.W. 1977. Breadmaking properties of four concentrated plant proteins. *Cereal Chem.* 54:1124.
- Frazier, P.J., Brimblecombe, F.A. and Daniels, N.W.R. 1977. The effect of lipxygenase action on the mechanical development of doughs from fat-extracted and reconstituted wheat flours. *J. Sci. Food Agric.* 28:247.
- Hood, L.F. and O'Shea, G.K. 1977. Calcium binding by hydroxypropyl distarch phosphate and unmodified starches. *Cereal Chem.* 54:266.

- Hoseney, R.C., Rao, H., Faubion, J.M. and Sidhu, J.S. 1980. Mixograph studies. IV. The mechanism by which lipoxygenase increases mixing tolerance. *Cereal Chem.* 57:163.
- Khan, M.N. and Lawhon, J.T. 1980. Baking properties of oilseed protein and isolates produced with industrial membrane system. *Cereal Chem.* 57:433.
- Kieffer, R. and Grosch, W. 1980. Improvement of dough and baking properties of wheat flour by type. II. Lipoxygenase from soybeans. *Z. Lebensm. Unters. Forsch.* 170:258.
- Mizrahi, S., Zimmerman, G., Berk, Z. and Cogan, U. 1967. The use of isolated soybean proteins in bread. *Cereal Chem.* 44:193.
- Onayemi, O. and Lorenz, K. 1978. Soy concentrate and soy isolate in bread baking. *Baker's Dig.* 54(1):18.
- Paulsen, T.W. and Horan, F.E. 1965. Functional characteristics of edible soy flours. *Cereal Sci. Today* 10(1):14.
- Pollock, J.M. and Geddes, W.F. 1960a. Soy flour as a white bread ingredient. I. Preparation of raw and heat-treated soy flours, and their effects on dough and bread. *Cereal Chem.* 37:19.
- Pollock, J.M. and Geddes, W.F. 1960b. Soy flour as a white bread ingredient. II. Fractionation of raw soy flour and effects of the fractions in bread. *Cereal Chem.* 37:30.
- Pomeranz, Y., Shogren, M.D. and Finney, K.F. 1969a. Improving baking properties with glycolipids. II. Various protein-enriched products. *Cereal Chem.* 46:512.
- Pomeranz, Y., Shogren, M.D. and Finney, K.F. 1969b. Improving baking products with glycolipids. I. Improving soy products with sucroesters. *Cereal Chem.* 46:503.
- Pomeranz, Y. and Chung, O.K. 1978. Interaction of lipids with proteins and carbohydrates in breadmaking. *J. Am. Oil Chem. Soc.* 55:285.
- Ranhotra, G.S., Loewe, R.J. and Lehmann, T.A. 1974. Breadmaking characteristics of wheat flour fortified with various commercial soy protein products. *Cereal Chem.* 51:629.
- Rasper, V.F., Rasper, J. and deMan, J.M. 1974. Stress-strain relationships of chemically improved unfermented doughs. I. The evaluation of data obtained at large deformation in simple tensile mode. *J. Texture Stud.* 4:438.
- Rasper, V.F. 1975. Dough rheology at large deformations in simple tensile mode. *Cereal Chem.* 52:24r.
- Rasper V.F. and deMan, J.M. 1980. Measurement of hydration capacity of wheat flour/starch mixtures. *Cereal Chem.* 57:27.
- Rooney, L.W., Gustavson, C.B., Clark, C.M. and Clark, C.P. 1972. Comparison of baking properties of several oil seed flours. *J. Food Sci.* 37:14.
- Sipos, E.F., Turro, E. and Williams, L.D. 1974. Soy protein products for baked foods. *Baker's Dig.* 48(1):29.
- Tanaka, K. and Tipples, K.H. 1969. Relation between farinograph mixing curves and mixing requirements. *Cereal Sci. Today* 14:296.
- Townsend, A.A. 1977. Some properties of doughs supplemented with soy and pea protein isolates. M.Sc. Thesis. University of Guelph, Guelph, ON.
- Tsen, C.C., Hoover, W.J. and Philips, D. 1971. High-protein breads. Use of sodium stearoyl-2-lactylate and calcium stearoyl-2-lactylate in their production. *Baker's Dig.* 45(2):20.
- Yasamatsu, K., Sawada, K., Moritaka, S., Toda, J., Wade, T. and Ishii, K. 1972. Effects of addition of soybean products on dough properties. *Agric. Biol. Chem. (Tokyo)* 36:729.

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RESEARCH NOTE

Gross Energy Values of Oils from High and Low Erucic Acid Rapeseed Oils and of Rapeseed Gums

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Abstract

Oils from seven rapeseed cultivars ranging in erucic acids levels from 0-59%; a commercial low erucic acid, refined oil; purified samples of linoleic, linolenic, caprylic, arachidonic and erucic acids; commercial and refined lecithin, egg lecithin and acetone-extracted rapeseed lecithin from low erucic acid rapeseed oil and glycerol tripalmitate, were analyzed for fatty acids by gas liquid chromatography and for gross energy (heat of combustion) by adiabatic bomb calorimetry. The oils ranged from 39.4-40.6 kJ/g (9.4-9.7 Kcal/g), reflecting the higher values of the C:22 component for the high erucic acid cultivars. Rapeseed gums (oil-free) contained 30.2 kJ/g (7.22 Kcal/g). The gross energy value of raw gums, available for digestion and potentially effective as a dietary energy source, was estimated to be between 28.9-30.5 kJ/g (6.9 and 7.3 Kcal/g) depending mainly on the prevailing content of rapeseed oil.

Résumé

On a fait le dosage des acides gras à l'aide de chromatographie en phase gazeuse et liquide, et la détermination de l'énergie brute (chaleur de combustion) à l'aide de la bombe calorimétrique adiabatique sur les huiles de sept cultivars de colza ayant des teneurs en acide érucique entre 0 et 59%, sur une huile raffinée du commerce faible en acide érucique, sur des échantillons purifiés d'acides linoléique, linoléique, caprylique, arachidonique et érucique, sur des lécithines du commerce et raffinées, sur de la lécithine d'oeuf, sur de la lécithine de colza extraite à l'acétone et provenant d'huile de colza faible en acide érucique, et sur du tripalmitate de glycérol. Les huiles ont varié entre 39,4-40,6 kJ/g (9,4-9,7 Kcal/g), tel qu'anticipé d'après les fortes teneurs en C:22 des cultivars riches en acide érucique. Les gommages de colza (sans huile) eurent 30,2 kJ/g (7,22 Kcal/g). La valeur énergétique brute des gommages crus, qui peuvent être digérées et qui peuvent servir comme source énergétique fut évaluée entre 28,9-30,5 kJ/g (6,9-7,3 Kcal/g) suivant surtout l'importance de la présence d'huile de colza.

Introduction

In a recent study of the nutritional value of gums derived from the refining of rapeseed oil (McCuaig and Bell, 1981), it became apparent that there were no published data on the gross energy (heat of combustion) values of gums. The chemical nature of rapeseed gums has been described (Weenink and Tullock, 1966; Persmark, 1968; Niewiadomski, 1970; Appelqvist and Ohlson, 1972). At

the time of removal from rapeseed oil they contain 35-40% rapeseed oil and about 43% phosphatidyl compounds and several minor components.

It also became apparent that the gross energy values were not available for the oils from the various cultivars of rapeseed, nor for several of the longer chain fatty acids typical of rapeseed oil. It was observed, however, that the longer chain fatty acids have higher gross energy values than the shorter ones (International Critical Tables, 1929), a factor of possible interest when comparing low and high erucic rapeseed oils.

Materials and Methods

Purified linoleic, linolenic, caprylic, arachidonic and erucic acids were obtained from the United States Biochemical Corporation, Cleveland, Ohio. Commercial soybean lecithin, refined soybean lecithin, egg lecithin and glycerol tripalmitate were obtained from the same supplier. Acetone-extracted rapeseed gums from low erucic acid cultivars (Canola) were provided by the POS Pilot Plant Corporation, Saskatoon, Sask. Seven types of *Brassica* oil samples, hexane extracted and from cultivars having oils ranging from 0-50% erucic acid, were obtained from the Research Station, Agriculture Canada, Saskatoon, Sask. The oils were obtained from three high erucic acid cultivars: *B. campestris* R-500 and *B. napus* Target and Bronowski, and from four low erucic acid cultivars: *B. campestris* Torch and *B. napus* Midas, Regent and Altex. In addition, one commercial sample of Canola oil derived from a blend of *B. napus* and *B. campestris* low erucic acid seed was obtained. These oils were dried to remove moisture and residual hexane (AOAC, 1980; Section 28.002) and were analyzed in duplicate for fatty acid composition by gas liquid chromatography (Stringam and McGregor, 1980) at the Research Station.

The gross energy values were determined in triplicate using an adiabatic oxygen bomb calorimeter.

Results and Discussion

The fatty acid composition of the *Brassica* oils (Table 1) indicates no significant amounts of fatty acids C16:0, C16:1, C18:0, C20:0, C22:0, C24:0 and C24:1. No C14:0 was found or, if any, trace amounts. The high erucic acid oils (R-500, Target and Bronowski) contained more C20:1 than the other oils and had lower levels of oleic acid (C18:1).

The gross energy values for the oils (Table 2) show a tendency for the values to decrease slightly as the percentage of erucic acid in the oil declines. This is in accord with the relationship between the length of the carbon chain of the fatty acid and its gross energy value (Figure 1). Thus, the selection for high or low erucic acid in *Brassica* may be expected to affect the gross energy value of the oil. However, the range of values will be confined to about 39.3-40.6 kJ/g (9.4-9.7 Kcal/g)

because of the very limited variability in amounts of C24 fatty acids and the near absence of fatty acids below C16.

The degree of unsaturation of fatty acids, and likewise the hydrogenation of oil containing unsaturated fatty acids, will affect the gross energy value. The unsaturated acids have slightly lower values than their saturated counterparts (Figure 1).

The gross energy values of gums and lecithins (Table 2) indicate values of 30.2 kJ/g (7.22 Kcal/g) for oil-free Canola rapeseed gums and 31.2 kJ/g (7.46 Kcal/g) for refined soybean lecithin. Egg and soybean lecithin, typical of the products sold in the food trade, contain some residual oil and consequently have higher energy values.

Knowing the gross energy values of rapeseed oil and of oil-free gums, it is now possible to estimate the gross energy value for raw gums if the percentage of oil is

Table 1. Fatty acid composition of selected *Brassica* oils (%).

Fatty acid	R-500 (isolation)	R-500 (commercial)	Target	Bronowski	Canola (commercial)	Torch	Regent	Midas	Altex
C14:0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C16:0	1.7	1.5	2.7	2.7	3.5	3.0	3.7	3.5	4.0
C16:1	0.0	0.3	0.2	0.3	0.2	0.4	0.4	0.4	0.5
C18:0	0.9	0.8	1.0	1.3	1.4	1.3	1.5	1.5	1.4
C18:1	12.3	13.8	20.6	31.5	56.1	59.1	58.0	58.9	56.9
C18:2	12.7	13.2	13.8	14.7	23.2	21.9	22.9	21.8	23.8
C18:3	7.6	8.2	6.2	10.0	11.0	10.6	9.8	10.5	10.1
C20:0	1.2	1.1	1.0	1.0	1.1	0.9	1.1	1.1	1.1
C20:1	5.8	5.9	13.2	15.1	2.0	1.7	1.7	1.5	1.5
C22:0	0.9	0.8	0.4	0.2	0.3	0.2	0.3	0.3	0.3
C22:1	54.8	52.4	39.8	21.9	0.8	0.6	0.1	0.1	0.0
C24:0	0.5	0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.1
C24:1	1.6	1.6	0.9	1.1	0.3	0.2	0.3	0.2	0.3

Table 2. Gross energy values of selected *Brassica* oils, tripalmitin, glycerol and phospholipids.

Sample description	Erucic acid (%)	Gross energy	
		Kcal/g	kJ/g
Erucic acid	100.0	9.80	41.00 ± 0.13 ¹
R-500, isolation seed	59.4	9.75	40.79 ± 0.06
R-500, commercial	54.8	9.70	40.58 ± 0.05
Target rapeseed	39.8	9.76	40.84 ± 0.16
Bronowski rapeseed	21.9	9.66	40.42 ± 0.10
Canola rapeseed, commercial	0.8	9.57	40.04 ± 0.14
Torch rapeseed	0.6	9.66	40.42 ± 0.16
Regent rapeseed	0.1	9.60	40.07 ± 0.00
Midas rapeseed	0.1	9.66	40.42 ± 0.16
Altex rapeseed	0.0	9.60	40.17 ± 0.04
Tripalmitin	0.0	9.41	39.37 ± 0.02
Glycerol	0.0	4.30	18.00 ²
Caprylic acid	0.0	8.05	33.68 ± 0.22
Linoleic acid	0.0	9.49	39.71 ± 0.19
Linolenic acid	0.0	9.42	39.41 ± 0.08
Arachidonic acid	0.0	9.54	39.92 ± 0.09
Canola gums, acetone extracted	0.0	7.22	30.21 ± 0.05
Soy lecithin	0.0	8.05	33.68 ± 0.05
Soy lecithin, refined	0.0	7.46	31.21 ± 0.02
Egg lecithin	0.0	8.47	35.44 ± 0.06

¹Standard deviations.
²Obtained from CRC Handbook of Chemistry and Physics (Anon., 1980).

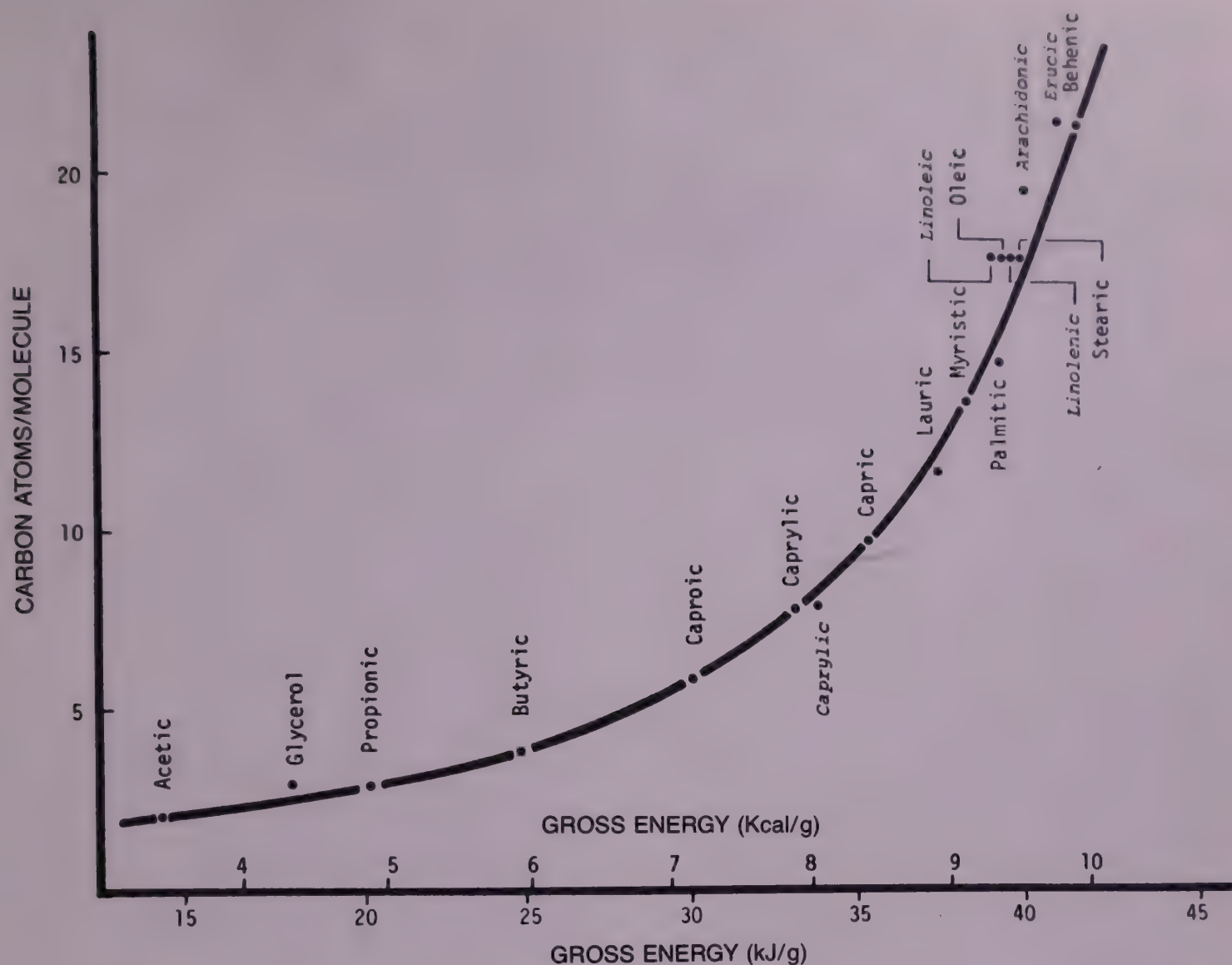


Fig. 1. Gross energy values for the major fatty acids found in foodstuffs shown in relation to the number of carbon atoms in the molecule. (Values in *italics* were determined in this experiment; the others are published values, International Critical Tables, 1929.)

known. Using Appelqvist and Ohlson's (1972) statement that such gums contain 30-40% oil, the gross energy value would therefore range between 33.1 and 34.1 kJ/g (7.92 and 8.16 Kcal/g).

It may be difficult or impossible to obtain reliable digestible energy (DE) or metabolizable energy (ME) values for gums by conventional methods because of their chemical nature and because of the problem of feeding sufficiently high percentages of gums in the diet to establish reliable digestibility values. They contain phosphates, choline, ethanolamine, inositol and other minor constituents. A typical phospholipid molecule contains glycerol and two molecules of fatty acid (mainly C18:1 and C18:2; Persmark, 1968) and these are potential sources of DE and ME. If the nonlipid constituents of gums are disregarded as energy sources, the effective gross energy value of raw gums containing 30 or 40% rapeseed oil lies between 28.9 and 30.5 kJ/g (6.9 and 7.3 Kcal/g). Digestion coefficients appropriate for rapeseed (Canola) oil could be applied to these adjusted gross energy values to obtain DE values for any particular class of animal.

This study has provided information on the gross energy values for a range of rapeseed oils, varying widely

in erucic acid levels, for several fatty acids present in rapeseed oils, for rapeseed gums (oil-free) and for several types of food grade lecithin. In addition, a basis for estimating the digestible energy value of rapeseed gums is provided.

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References

- Anon. 1980. CRC Handbook of Chemistry and Physics. 61st Edition. R.C. Weast (Ed.). CRC Press Inc., Boca Raton, FL.
- AOAC. 1980. Official Methods of Analysis, 13th ed. Association of Official Analytical Chemists, Washington, DC.

- Appelqvist, L.-Å. and Ohlson, R. 1972. Rapeseed. Cultivation, Composition, Processing and Utilization. Elsevier Publishing Company, Amsterdam, The Netherlands.
- International Critical Tables. 1929. Prepared for the National Research Council (U.S.A.) by McGraw-Hill Book Co., New York, NY.
- McCuaig, L.W. and Bell, J.M. 1981. Effects of rapeseed gums on the feeding value of diets for growing-finishing pigs. *Can. J. Anim. Sci.* 61:463.
- Niewiadomski, H. 1970. Improvement of rapeseed lecithin for edible purposes. *In: Proceedings of the International Conference on the Science, Technology and Marketing of Rapeseed and Rapeseed Products.* p. 223. Rapeseed Association of Canada, Winnipeg, MB.
- Persmark, U. 1968. Main constituents of rapeseed lecithin. *J. Am. Oil Chem. Soc.* 45:742.
- Stringam, G.R. and McGregor, D.I. 1980. Inheritance of fatty acid composition of a yellow-embryo mutant in turnip rape (*B. campestris*, L.). *Can. J. Plant Sci.* 60:97.
- Weenink, R.O. and Tullock, A.P. 1966. The major component phospholipids of rapeseed gums. *J. Am. Oil Chem. Soc.* 43:327.

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RESEARCH NOTE

An Improved Method for Milling Semolina in the Buhler Laboratory Mill and a Comparison to the Allis-Chalmers Laboratory Mill¹

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Abstract

A mill flow is described which produces a 70% extraction of granulars (65% extraction semolina) from a sound durum wheat in the Buhler laboratory mill when used in conjunction with a laboratory purifier. Compared to the Allis-Chalmers laboratory mill, the Buhler laboratory mill was equally sensitive to variations in wheat semolina milling potential. A wide range of semolina and spaghetti quality tests revealed the Buhler laboratory mill to be an equally reliable predictor of semolina end use quality compared to the standard Allis-Chalmers laboratory mill.

Résumé

Ce rapport porte sur la description d'un courant de moulin qui produit une extraction à 70% de granules (65% de semoule) à partir d'un blé durum sain dans un moulin de laboratoire Buhler utilisé conjointement avec un purificateur de laboratoire. Par comparaison au moulin de laboratoire Allis-Chalmers, le moulin Buhler a réagi aussi bien aux variations dans la possibilité de mouture de la semoule de blé. Il a été possible de démontrer sur une grande marge de qualité de semoule et de spaghetti que le moulin de laboratoire Buhler était un moyen aussi viable que le moulin Allis-Chalmers pour prédire la qualité d'usage de la semoule.

Introduction

The aim of durum wheat quality control laboratories is to provide information on which sound judgement can be based regarding milling properties and end use quality from a small quantity of durum wheat. The first and perhaps most important step in durum wheat quality evaluation is the development of a reliable laboratory scale milling procedure which yields semolina of comparable extraction and quality to that obtained from a commercial semolina mill flow. Recently we have developed

a modified milling flow using a three-stand Allis-Chalmers laboratory mill which, in conjunction with a laboratory purifier (Black, 1966), yields a semolina of comparable extraction, granulation and spaghetti making quality to commercial semolina (Dexter and Matsuo, 1978; Matsuo and Dexter, 1980a).

The Grain Research Laboratory receives many requests from quality control labs around the world for assistance in development of durum wheat laboratory milling procedures. Unfortunately, the Allis-Chalmers laboratory mill is no longer available commercially. Since most quality control labs are equipped with a Buhler laboratory mill we felt it would be desirable to develop a scheme for milling durum wheat in the Buhler laboratory mill to yield semolina of comparable extraction and quality to commercial semolina. Previous reports (Black and Bushuk, 1967; Sollberger, 1970) have described how, with some minor modifications, the Buhler laboratory mill can be used to produce durum wheat semolina of good quality. However, in both cases the extraction rate of the semolina was much below the normal commercial semolina extraction range of 63-68%. In this communication we describe a method for obtaining a 65% extraction semolina from a Buhler laboratory mill (total extraction including flour of about 70%) and compare the quality of the product to that produced by the Allis-Chalmers laboratory mill system.

Materials and Methods

Wheat

Reproducibility of milling performance and quality characteristics were determined for each mill with composite samples of No. 1 Canada Western amber durum

¹Contribution No. 485 from the Grain Research Laboratory.

(CWAD), No. 2 CWAD and No. 3 CWAD from the 1980 Canadian new crop survey. Samples were milled in each mill ten times on ten different days.

A further comparison between the two mills was performed from single millings of the following series of samples representing a wide range in milling potential and semolina properties:

- a No. 1 CWAD sample sieved to yield a sample with very large kernels (weight/1,000 kernels 54 g),
- a No. 2 CWAD sample of low protein (10.1%),
- a very poor quality (No. 5 CWAD) sample of low test weight (74.7 kg/hL), and
- a No. 1 CW red spring (RS) wheat.

Milling

The laboratory purifier described by Black (1966) was used in conjunction with both laboratory mills. All samples were tempered to 16.5% moisture for 18 h prior to milling. The mill room was controlled for temperature (22°C) and humidity (RH 60%).

The modified long milling flow for the three-stand Allis-Chalmers mill has been described previously (Dexter and Matsuo, 1978; Matsuo and Dexter, 1980a).

The Buhler laboratory mill was modified as described by Black and Bushuk (1967), but the mill flow was lengthened to increase semolina extraction and roll gaps were changed to yield a more granular product. A flow sheet is shown in Figure 1. Only the break system of the mill was used. Following passage of stock through the third break (B3), middlings were purified, branny purifier stock passed through the third break rolls again (B4), and middlings purified. This was followed by a final passage of rich branny stock through the third break rolls (B5) and final purification. The break rolls were run dull with a 2:1 speed differential (fast roll speed 500 rpm). Roll gaps were set at 0.086 cm, 0.030 cm and 0.020 cm for B1, B2 and B3, respectively. Production of middlings as measured by release of stock through a twenty wire sieve was about 18%, 69% and 80% for B1, B2 and B3, respectively, for a typical good quality durum wheat. Feed rate to B1 was 40 g of wheat/cm of roll surface per min. When flour through the 10 XX rebolt is included in the final product (granulars), a milling yield of about 70% (clean wheat basis) is achieved for sound

durum wheat. Semolina yield (flour excluded) will be somewhat lower depending on the proportion of flour produced during milling.

Cumulative ash curves were calculated by gathering streams following every second purification, the 10 XX overs and the 10 XX throughs, weighing each stream and determining ash levels.

Quality Testing

Wheat test weight, thousand kernel weight and semolina sieve analyses were performed as described by Matsuo and Dexter (1980b). Ash, wet gluten and yellow pigment were determined as described by Dexter and Matsuo (1978). Protein content (% N x 5.7 on a 14% moisture basis) was determined by a modified Kjeldahl method (Williams, 1973). The method of Irvine *et al.* (1961) was used for pasta dough farinograms. Mixing time was defined as the time required to reach maximum consistency. Tolerance index was the decrease in consistency 4 min past the peak, and bandwidth also was measured at that point. Semolina specks were determined as described by Dexter and Matsuo (1981).

Spaghetti was processed by a micromacaroni method (Matsuo *et al.*, 1972) and dried with a controlled decrease in relative humidity at 39°C over a 29 h period. Spaghetti colour was measured by the method of Daun (1978). Brightness is a measure of the amount of light reflected by a sample relative to the amount reflected by a near perfect white surface. Purity is a measure of colour intensity. Dominant wavelength is the wavelength of the pure spectrum colour which, in combination with a tungsten lamp source, produces the colour, and is thus a measure of colour hue. Textural characteristics of cooked spaghetti were evaluated on an apparatus described by Matsuo and Irvine (1969, 1971) at normal cooking time (about 12 min) and after overcooking 10 min. Tenderness index is a measure of shear rate under increasing force (firmness indicator), compressibility is a measure of deformation under constant force and recovery a measure of resilience.

Results and Discussion

Based on single test results for each of the ten semolina samples milled in the Buhler laboratory mill and the Allis-Chalmers laboratory mill from the No. 1 CW, No. 2 CW and No. 3 CWAD composites, the reproducibility of quality evaluation was comparable for either mill. Results for the No. 1 CW sample are given as an example (Table 1). The majority of the variability in test results was due to real day to day variations in semolina properties, i.e., for each mill when semolina was milled more than once on the same day, quality test results were very similar (results not presented). Often the number of samples to be screened for quality exceeds the daily mill capacity. Where this is the case, day to day quality variations can be accounted for by milling a control sample each milling day.

Comparative test results for single millings of four diverse wheats milled by each mill on the same day (Table 1) revealed the mills to be equally sensitive to variations in milling quality as reflected by both relative milling yield and semolina yield. The samples ranked in

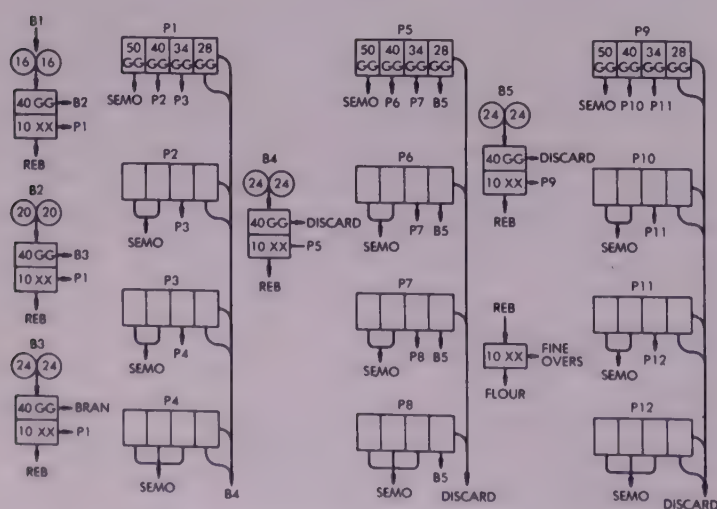


Fig. 1. Milling flow sheet for semolina milling in the Buhler laboratory mill.

Table 1. Comparison of important quality characteristics for a series of diverse wheats when milled by the Allis-Chalmers laboratory mill and the Buhler laboratory mill.

Property	No. 1 CWAD ¹				Sieved No. 1 CWAD ¹		No. 2 CWAD ¹		No. 5 CWAD ¹		No. 1 CWR ¹	
	Allis-Chalmers ²		Buhler ²		Allis-Chalmers ³	Buhler ³	Allis-Chalmers ³	Buhler ³	Allis-Chalmers ³	Buhler ³	Allis-Chalmers ³	Buhler ³
	Mean	SD	Mean	SD								
Wheat												
Milling yield (%)	69.35	0.51	68.53	0.43	70.9	71.1	69.8	70.3	62.4	62.1	62.6	63.0
Semolina yield (%)	65.99	0.50	65.32	0.33	67.9	68.5	65.7	65.8	59.1	58.7	54.2	54.8
Semolina												
Ash ⁴ (%)	0.665	0.009	0.628	0.14	0.65	0.61	0.55	0.51	0.69	0.65	0.42	0.37
Protein ⁴ (%)	12.45	0.10	12.29	0.07	12.2	12.1	9.2	9.0	13.3	13.0	12.7	12.4
Wet gluten ⁴ (%)	31.18	1.29	31.35	1.31	32.8	32.5	23.2	23.4	30.8	31.2	31.8	31.4
Specks/250 cm ²	13.5	7.3	16.5	7.5	14	27	28	35	43	59	209	203
Pigment (ppm)	5.60	0.099	5.611	0.114	4.92	4.90	7.42	7.38	6.09	6.23	2.45	2.33
Sieve analysis (%):												
held on #40	12.78	0.74	12.05	0.62	12.9	11.8	12.8	12.6	14.2	12.9	10.2	8.2
#60	66.47	1.07	65.07	0.76	65.1	63.7	64.8	64.0	65.2	63.6	59.8	61.0
#80	12.75	0.34	15.07	0.39	13.1	15.0	13.4	14.2	12.9	14.7	16.8	18.8
#100	3.08	0.29	3.13	0.28	3.1	3.1	3.2	3.2	3.3	3.2	4.4	5.0
throughs	3.73	0.26	3.85	0.25	4.0	4.7	4.8	5.0	4.2	4.8	7.0	7.2
Farinograph:												
mixing time (min)	4.78	0.38	4.68	0.29	5.25	5	8.75	6.5	5.25	5	3.75	3.5
tolerance index (BU ¹)	72.5	9.8	64.0	8.4	55	60	50	50	105	110	80	50
bandwidth (BU ¹)	89.5	5.0	90.0	7.8	105	90	70	35	55	50	110	100
Spaghetti												
Pigment ⁴ (ppm)	4.090	0.254	4.213	0.229	3.14	3.55	5.11	5.32	4.16	4.45	1.73	1.81
Pigment loss (%)	27.02	3.67	24.95	2.82	36.2	27.6	31.1	27.9	31.7	28.6	29.4	22.3
Colour:												
brightness (%)	46.60	1.09	47.36	0.70	47.8	48.5	50.2	51.0	44.3	44.4	42.8	46.7
purity (%)	57.57	1.99	57.93	2.11	53.0	54.3	60.5	60.0	55.6	56.8	43.2	43.3
dominant wavelength (nm)	577.81	0.11	577.64	0.13	577.8	577.6	577.4	577.4	578.2	578.2	579.1	578.3
Cooking:												
compressibility (%)	73.0	2.4	72.6	1.7	73	79	82	89	69	75	76	74
recovery (%)	36.4	4.4	35.1	3.2	36	35	20	12	43	35	30	24
tenderness index (m/sec x 10 ⁻⁶)	42.4	3.9	40.4	1.7	45	46	52	54	45	44	40	41
Overcooking:												
compressibility (%)	69.3	1.9	70.2	1.7	71	70	100	75	77	69	71	69
recovery (%)	47.2	4.5	45.6	3.4	48	44	0	32	35	43	39	43
tenderness index (m/sec x 10 ⁻⁶)	52.0	3.2	53.1	4.1	54	54	69	64	55	52	54	50

¹CW = Canada Western; AD = amber durum; RS = red spring; SD = standard deviation; BU = Brabender units.

²Milled ten times on separate days.

³Results from single millings.

⁴Expressed on 14% moisture basis.

similar order of quality for all semolina and spaghetti tests performed when milled in either mill.

The major difference in semolina quality between the two mills was the consistently lower ash for the Buhler milled semolina (Table 1). A plot of cumulative ash vs. cumulative semolina yield for both mills revealed a significantly lower semolina ash for Buhler milled semolina over the complete semolina yield range (Figure 2). The lower ash of the Buhler milled semolina led to the expected superior spaghetti colour characteristics (Matsuo and Dexter, 1980a) compared to Allis-Chalmers milled semolina (Table 1). These included a tendency to lower pigment loss during processing, higher brightness values and shorter dominant wavelengths (less tendency to brownness). As pointed out by Eva and Fisher (1957), the relative milling performance of different Buhler mills is quite variable, so there is no guarantee that the advantage of lower ash in Buhler milled semolina would be apparent for all Buhler laboratory mills. Nevertheless, based on the current study it is reasonable to assume that all Buhler laboratory mills would rank a series of samples of diverse quality in the same order.

Results of the current study have demonstrated that the Buhler laboratory mill can be used successfully to yield semolina of comparable extraction and spaghetti making quality to the Allis-Chalmers laboratory mill. Being an automatic mill, the Buhler laboratory mill has the added advantage of not requiring the operator to possess as

much milling expertise as the Allis-Chalmers laboratory mill. However, whereas only one sample can be milled in the Buhler mill at one time, several samples can be milled simultaneously in a batch mill such as the Allis-Chalmers laboratory mill. Thus, although the time to mill single samples is comparable for both mills (about 45 min for a 1 kg sample), where large numbers of samples are being assessed the Allis-Chalmers mill has the ability to mill up to 50% more samples in a given day than the Buhler laboratory mill.

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References

- Black, H.C. 1966. Laboratory purifier for durum semolina. *Cereal Sci. Today* 11:533.
- Black, H.C. and Bushuk, W. 1967. Modification of the Buhler laboratory mill for milling semolina. *Cereal Sci. Today* 12:164.
- Daun, J.K. 1978. Mathematical model for estimating color of spaghetti and mustard flour. *Cereal Chem.* 55:692.
- Dexter, J.E. and Matsuo, R.R. 1978. Effect of semolina extraction rate on semolina characteristics and spaghetti quality. *Cereal Chem.* 55:841.
- Dexter, J.E. and Matsuo, R.R. 1981. Effect of starchy kernels, immaturity and shrunken kernels on durum wheat quality. *Cereal Chem.* 58:395.
- Eva, W.J. and Fisher, M.H. 1957. Studies on variance in Buhler mills, with a bibliography on experimental milling. *Cereal Sci. Today* 2:124.
- Irvine, G.N., Bradley, J.W. and Martin, G.C. 1961. A farinograph technique for macaroni doughs. *Cereal Chem.* 38:153.
- Matsuo, R.R. and Irvine, G.N. 1969. Spaghetti tenderness apparatus. *Cereal Chem.* 46:1.
- Matsuo, R.R. and Irvine, G.N. 1971. Note on improved apparatus for testing spaghetti tenderness. *Cereal Chem.* 48:554.
- Matsuo, R.R., Bradley, J.W. and Irvine, G.N. 1972. Effect of protein content on the cooking quality of spaghetti. *Cereal Chem.* 49:707.
- Matsuo, R.R. and Dexter, J.E. 1980a. Comparison of experimentally milled durum wheat semolina to semolina produced by some Canadian commercial mills. *Cereal Chem.* 57:117.
- Matsuo, R.R. and Dexter, J.E. 1980b. Relationship between some durum wheat physical characteristics and semolina milling properties. *Can. J. Plant Sci.* 60:49.
- Sollberger, H. 1970. Lab grinding test for durum semolina. *The Miller* (October):8.
- Williams, P.C. 1973. The use of titanium dioxide as catalyst for large-scale Kjeldahl determination of the total nitrogen content of cereal grains. *J. Sci. Food Agric.* 24:343.

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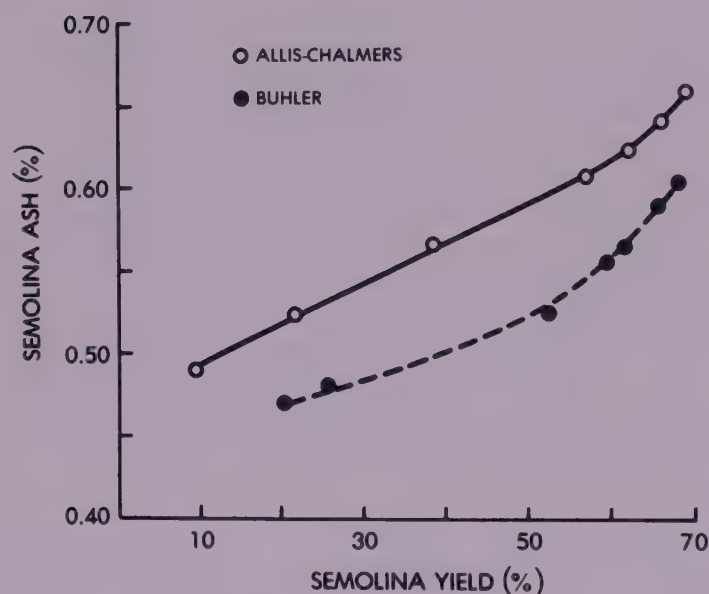


Fig. 2. Cumulative semolina ash curves for a No. 1 CWAD sample milled in the Allis-Chalmers and Buhler laboratory mills.

RESEARCH NOTE

Effect of Sex, Age and Carcass Cut on Composition of Harp Seal (*Phoca groenlandica*)¹ Meat

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Abstract

As part of a program to investigate utilization of meat recoverable from the inshore Newfoundland seal hunt, iodine number and proximate composition of prime cuts (flank, flipper and rump) of harp seals of five different ages were determined. The sex of the seal did not affect any of the chemical variables analyzed. Age affected mainly moisture and protein content, whereas carcass cut affected mainly fat, moisture and protein content. In general, the ash, moisture and protein contents were higher, and the fat content much lower than that of meat of domesticated terrestrial animals. Iodine numbers ranged from 90.1 to 144.8.

Résumé

En tant du programme d'utilisation de la viande recouvrable de la chasse des phoques sur la côte de Terre-Neuve, l'analyse de l'indice d'iode et de la composition proximative furent faites sur les tranches principaux (flanx, nageoire et culotte) des phoques de cinq différents âges. Le sex des phoques n'a pas affecté aucun des variables chimiques analysés. L'âge influença le contenu d'humidité et de protéines, alors que les tranches de la carcasse affectent le contenu du gras, d'humidité et de protéines. En général, le contenu de cendre, d'humidité et de protéines était plus élevé dans la viande du phoque que dans la viande d'animaux terriens domestiqués alors que le contenu de gras était moins élevé. L'indice d'iode avait des valeurs entre 90,1 et 144,8.

Introduction

During the last 5 years, a total of 324,219 harp seals have been slaughtered for pelts by the Newfoundland inshore seal hunters (Anon., 1977-81), giving a total of 4,379,508 kg of harp seal meat (Botta *et al.*, 1980) that was available for human consumption. However, very little is known about its composition. Consequently, as part of a program to investigate utilization of meat recoverable from the inshore Newfoundland seal hunt, the present study was undertaken to determine the iodine number and proximate composition of harp seal (*Phoca groenlandica*) meat.

¹Also known as *Pagophilus groenlandicus*.

Materials and Methods

Raw Materials

Beaters, bedlamers and harps (Table 1), the major classes of harp seal slaughtered during the inshore Newfoundland hunt, were shot on March 3, March 10 and April 15, 1980, in White Bay, Newfoundland. The animals were immediately bled and shortly thereafter eviscerated, skinned, placed inside heavy duty plastic bags and stored in flake ice until butchered 3 days later. The age of each carcass was determined by counting, under polarized light, the dentinal annuli of thinly sectioned (approximately 100 μ thick) canine teeth (Fisher, 1954). All carcasses were butchered into the various cuts shown in Figure 1.

The prime cuts (flank, flipper and rump) were retained, the surface fat trimmed off and the excess blood removed by cool water rinses. The trimmed and rinsed cuts were individually passed three times through a meat grinder, with 7 mm diameter holes. A small portion of the ground seal meat was placed in a plastic bag, frozen at -40°C , immediately transferred to 100 μ thick polyamide polyethylene pouches and then vacuum packaged using a CDL Model 212 vacuum sealing machine. The vacuum,

Table 1. Glossary of terms concerning classes of harp seal (*Phoca groenlandica*).

Whitecoat	A newborn harp seal up to an age of about 12 days, prior to loss of the soft white natal fur.
Ragged-Jacket	A young harp seal undergoing its first molt from a whitecoat to a beater. Age ranges between 12 and 18 days.
Beater	A young harp seal in its first year of life, having completed its first molt to a spotted grey coat. Age when slaughtered ranges between 3 and 8 weeks.
Bedlamer	A juvenile seal in its second, third or fourth year of life, having a spotted coat.
Harp	A seal at least 5 years of age.

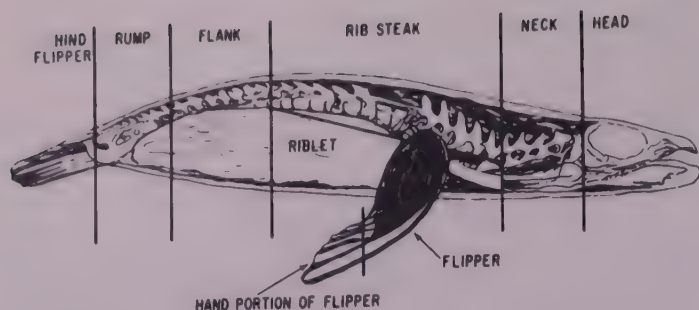


Fig. 1. Carcass cuts of the harp seal (*Phoca groenlandica*).

seal and cool settings were 2, 2 and 1.5, respectively, and during packaging the vacuum level reached 71.3 cm of mercury. The vacuum packaged samples were stored at -40°C until determination of total lipid was conducted. If necessary, the samples were repackaged every 2 mo. All analyses were conducted within 8 mo of initial packaging. The major portion of the ground seal meat was transferred to a 450 mL capacity polyethylene tub with a tight fitting lid, then frozen and stored at -35°C . Moisture determination of each sample was initiated within 3 days of the sample being frozen.

Chemical Analysis

Moisture content was determined by placing 30-60 g of ground seal meat into a preweighed glass dish, maintaining the sample in a 100°C hot air oven for 2 days and then reweighing it. The determination was repeated if the difference between duplicate samples was more than 1.0%. The dried sample was immediately passed through a mill containing a 20 mesh screen, promptly transferred to a plastic vial with a screw cap, then stored for further analysis.

Crude fat, crude protein and ash content of the dried

samples were determined using methods described by AOAC (1975).

Total lipid was extracted from the vacuum packaged samples using the method of Bligh and Dyer (1959) and the iodine number of this lipid was immediately determined using the Wijs method (AOAC, 1975).

Statistical Analyses

Analyses of variance were conducted on the chemical variables by using a one-way analysis of variance with sex as a fixed main effect, and by using a two-way analysis of variance with interaction of age and carcass cut which were the fixed main effects. If the age $\times$ cut interaction were not significant ($P > 0.05$), its sums of squares and degrees of freedom were pooled with the error sums of squares and degrees of freedom resulting in a two-way analysis of variance without interaction. If this analysis of variance indicated that either age or cut significantly ($P \leq 0.05$) affected the variable, the Studentized Range Test (Snedecor and Cochran, 1967) was conducted to determine differences within each main effect. Unless otherwise stated, "significant" means significant at the 5% level ($P \leq 0.05$).

Results and Discussion

The sex of the seal did not significantly affect the iodine number of the extracted lipid, or the moisture, crude protein and crude fat contents of the meat (Table 2). Although a one-way analysis of variance revealed that the ash content of female seal meat was significantly greater than that of male seal meat (Table 2), an unbalanced three-way analysis of variance with age, cut and sex as the main effects, after age and cut were accounted for, revealed that sex did not significantly affect ash content.

Table 2. Sex means, including standard deviations.¹

Sex	n	Ash content (%)	Moisture content (%)	Crude protein content (%)	Crude fat content (%)	Iodine number
Female	54	1.47a $\pm$ 0.38	72.79a $\pm$ 1.32	23.96a $\pm$ 1.56	1.19a $\pm$ 0.74	118.3a $\pm$ 10.9
Male	36	1.31b $\pm$ 0.32	73.11a $\pm$ 1.45	23.55a $\pm$ 1.73	1.36a $\pm$ 0.83	120.3a $\pm$ 10.3

¹Means not sharing the same letter are significantly ($P \leq 0.05$) different from each other.

Table 3. Age and carcass cut means, including standard deviations, and results of Studentized Range Test.¹

Age ²	Ash content (%)	Moisture content (%)	Crude protein content (%)
Beater	1.06a $\pm$ 0.15	74.97a $\pm$ 1.32	21.06a $\pm$ 0.91
1 year old bedlamer	1.46bc $\pm$ 0.31	72.28b $\pm$ 0.85	24.76b $\pm$ 1.08
2 year old bedlamer	1.27ab $\pm$ 0.27	72.56b $\pm$ 0.81	24.29b $\pm$ 0.91
3 year old bedlamer	1.64c $\pm$ 0.37	72.47b $\pm$ 0.88	24.27b $\pm$ 0.78
4 years or older	1.59c $\pm$ 0.35	72.30b $\pm$ 0.61	24.59b $\pm$ 0.66
Carcass cut ²			
Rump	1.33a $\pm$ 0.30	72.58a $\pm$ 1.20	23.54a $\pm$ 1.56
Flank	1.41a $\pm$ 0.42	72.56a $\pm$ 1.43	24.59b $\pm$ 1.59
Flipper	1.47a $\pm$ 0.35	73.60b $\pm$ 1.41	23.26b $\pm$ 1.49
Grand mean	1.40 $\pm$ 0.36	72.91 $\pm$ 1.37	23.79 $\pm$ 1.63

¹Means not sharing the same letter are significantly ($P \leq 0.05$) different from each other.

²n for each cut of each age = 6.

Age of harp seal significantly ($P \leq 0.001$) affected ash content of the meat but no consistent trend was observed (Table 3). The 74.98% moisture content of beater cuts was significantly greater than the 72.40% moisture content of bedlamer and adult cuts (Table 3). The reverse was true for crude protein content averaging 21.06% in beaters and 24.48% in older animals (Table 3). The protein content of 3 and 4 year old harp seals was comparable to that reported by Hoppner *et al.* (1978) for seal (species unknown) whereas the moisture content was noticeably lower.

The ash content was not significantly affected by carcass cut (Table 3). The moisture content of the flipper was 73.6%, whereas that of both flank and rump was significantly lower, averaging 72.6% (Table 3). However, the 24.59% crude protein content of flank was significantly greater than the 23.26% and 23.54% crude protein content of flipper and rump, respectively (Table 3).

Age x carcass cut interaction means indicated that crude fat of rump, but not of flank and flipper, noticeably decreased as age increased (Table 4). This was particularly true for beaters. The interaction means also indicated that the order of fat content was always flank (0.57-0.82%), flipper (0.98-1.37%) and rump (1.37-3.45%) (Table 4). The difference between flank and rump meat was most noticeable in beaters. The crude fat content of rump was similar to, but more variable than that reported by George *et al.* (1971), for gluteus and psoas muscles of the rump area of harp seal. However, the crude fat content of 3 and 4 year old harp seal was noticeably lower than that reported for seal (species unknown) by Hoppner *et al.* (1978).

Age x carcass cut interaction means indicated that iodine number of each cut varied with age, but no consistent trends were evident (Table 5). These means also suggested that iodine number of each age group varied with carcass cut and, except for the 2 year old bedlamers, the order was always flank (104.7-113.8), flipper (112.7-126.1) and rump (119.2-136.6) (Table 5). The observed values were much higher than those reported for intramuscular beef or pork fat (Lawrie, 1974), slightly to very much lower than those reported for lipids from fish (Ackman, 1966) and moderately lower than those reported for lipid extracted from blubber of harp seals (Jangaard and Ke, 1968).

Thus age and carcass cut, but not sex, affected the proximate composition of harp seal meat studied (Tables 2-5). However, these two variables also affect the proximate composition of meat of domesticated terrestrial animals (Byerly, 1975; Rice, 1978).

The proximate composition of harp seal meat and reported values for some common animals are shown in Table 6. In general, crude fat of harp seal meat studied was lower than that reported for both meat of domesticated terrestrial animals and flesh of fatty and medium fatty fish. This was even quite noticeable with lean beef, lamb and pork. It should be noted that very little (if any) marbling occurs in harp seal meat and fat content would thus depend on the degree of trimming of surface fat. Both crude protein and ash contents were noticeably higher than those reported for both meat of domesticated terrestrial animals and the flesh of most common commercial species of fish. The high protein content (also observed by Hoppner *et al.*, 1978) may be at least

Table 4. Age x carcass cut interaction means, including standard deviations, of percent crude fat content.

Age ¹	Carcass cut ¹			Overall mean of each age (n = 18)
	Rump	Flank	Flipper	
Beater	3.45 ± 0.50	0.82 ± 0.48	1.37 ± 0.36	1.88 ± 1.24
1 year old bedlamer	1.78 ± 0.51	0.60 ± 0.17	1.50 ± 0.43	1.29 ± 0.64
2 year old bedlamer	1.63 ± 0.33	0.63 ± 0.15	1.10 ± 0.42	1.12 ± 0.52
3 year old bedlamer	1.50 ± 0.42	0.57 ± 0.19	0.93 ± 0.25	1.00 ± 0.49
4 years or older	1.37 ± 0.29	0.62 ± 0.24	0.98 ± 0.19	0.99 ± 0.39
Overall mean of each carcass cut (n = 30)	1.95 ± 0.87	0.65 ± 0.26	1.18 ± 0.39	
Grand mean of entire sample (n = 90)				1.26 ± 0.78

¹n for each cut of each age = 6.

Table 5. Age x carcass cut interaction means, including standard deviations, of iodine number of extracted lipid.

Age ¹	Carcass cut ¹			Overall mean of each age (n = 18)
	Rump	Flank	Flipper	
Beater	136.6 ± 6.0	104.7 ± 11.3	112.7 ± 11.1	118.0 ± 16.7
1 year old bedlamer	129.1 ± 4.7	115.8 ± 3.2	126.1 ± 3.4	123.7 ± 6.8
2 year old bedlamer	119.2 ± 12.0	115.0 ± 8.3	123.6 ± 6.7	119.3 ± 9.4
3 year old bedlamer	124.2 ± 8.6	112.2 ± 6.6	113.8 ± 9.5	116.7 ± 9.6
4 years or older	123.6 ± 4.8	113.8 ± 6.3	115.7 ± 8.1	117.7 ± 7.6
Overall mean of each carcass cut (n = 30)	126.5 ± 9.4	112.3 ± 8.2	118.4 ± 9.4	
Grand mean of entire sample (n = 90)				119.1 ± 10.7

¹n for each cut of each age = 6.

Table 6. Composition of edible portion of various animals.

Species ¹	Ash (%) ²	Crude fat (%)	Crude protein (%)	Moisture (%)
Beef – lean	1.1	4.6	20.3	74.0
(raw) fat	0.3	66.9	8.8	24.0
Lamb – lean	0.3	8.8	20.8	70.1
(raw) fat	0.8	71.8	6.2	21.2
Pork – lean	0.7	7.1	20.7	71.5
(raw) fat	0.7	71.4	6.8	21.1
Chicken – raw meat only	0.8	4.3	20.5	74.4
Duck – raw meat only	0.5	4.8	19.7	75.0
Turkey – raw meat only	0.4	2.2	21.9	75.5
Harp seal – raw flank, flipper and rump	1.4	1.3	23.8	72.9
Cod – raw fillets	–	0.7	17.4	82.1
Haddock – raw fillets	1.3	0.6	16.8	81.3
Herring – raw flesh	0.8	18.5	16.8	63.9
Plaice – raw	0.4	2.2	17.9	79.5
Atlantic salmon – raw	1.6	12.0	18.4	68.0

¹Harp seal values were determined in the present study; all other compositional data are from Paul and Southgate (1978).

²Except for harp seal, ash values were determined by subtraction.

partially attributed to the high myoglobin content of harp seal muscle (George *et al.*, 1971). The observed proximate composition of harp seal meat was most similar to that reported for turkey.

Thus, the proximate composition (including iodine number of the lipid) of harp seal meat studied slightly exceeds that reported for meat of domesticated terrestrial animals and, in general, depending on the species, is comparable to or better than that reported for fish.

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References

Ackman, R.G. 1966. Empirical relationships between iodine value and polyunsaturated fatty acid content in marine oils and lipids. *J. Am. Oil Chem. Soc.* 43(6):385.
Anon. 1977-81. Annual Newfoundland seal catch statistics. Statistics and Computer Services, Economics Services Branch, Canada Department of Fisheries and Oceans, St. John's, NF.
AOAC. 1975. Official Methods of Analysis, 12th ed. Association of Official Analytical Chemists, Washington, DC.
Bligh, E.G. and Dyer, W.J. 1959. A rapid method of total lipid extraction and purification. *Can. J. Biochem. Physiol.* 37:911.
Botta J.R., Downey, A.P., Lauder, J.T. and Noonan, P.B. 1980.

Utilization of inshore Newfoundland-caught harp seal (*Pagophilus groenlandicus*): Sensory quality of frozen stored, salted and smoked seal meat. Fisheries and Environment Canada, Fisheries and Marine Service Technical Report No. 916.
Byerly, T.C. 1975. Effects of agricultural practices on foods of animal origin. *In: Nutritional Evaluation of Food Processing.* R.S. Harris and E. Karmas (Eds.). p. 58. AVI Publishing Company, Inc., Westport, CT.
Fisher, H.D. 1954. Studies on reproduction in the harp seal *Phoca groenlandica* (Erxleben), on the Northeast Atlantic. Ph.D. Thesis. McGill University, Montréal, QU.
George, J.C., Vallyathan, N.V. and Ronald, J. 1971. The harp seal, *Pagophilus groenlandicus* (Erxleben, 1777). VII. A histophysiological study of certain skeletal muscles. *Can. J. Zool.* 49:25.
Hoppner, K., McLaughlan, J.M., Shah, B.G., Thompson, J.N., Beare-Rogers, J., Ellestand-Sayed, J. and Schaefer, O. 1978. Nutrient levels of some foods of Eskimos from Arctic Bay, N.W.T., Canada. *J. Am. Diet. Assoc.* 73:257.
Jangaard, P.M. and Ke, P.J. 1968. Principal fatty acids of depot fat and milk lipids from harp seal (*Pagophilus groenlandica*) and hooded seal (*Cystophora cristata*). *J. Fish. Res. Board Can.* 25(11):2419.
Lawrie, R.A. 1974. Meat Science. 2nd Edition. Pergamon Press, Toronto, ON.
Paul, A.A. and Southgate, D.A.T. 1978. McCance and Widdowson's The Composition of Foods. Her Majesty's Stationery Office, London, England.
Rice, E.E. 1978. The nutritional content and value of meat and meat products. *In: The Science of Meat and Meat Products.* J.F. Price and B.S. Schweigert (Eds.). p. 287. Food & Nutrition Press, Inc., Westport, CT.
Snedecor, G.W. and Cochran, W.G. 1967. Statistical Methods. Sixth Edition. Iowa State University Press, Ames, IA.

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RESEARCH NOTE

Evaluation of the Green Sea Urchin Gonads as a Food Source

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Abstract

The yield of milt and roe from the green sea urchin (*Strongylocentrotus droebachiensis*) ranged from 30% and 22%, respectively, to less than 4% over a 1 year harvesting period. The gonads were most acceptable for eating during the early ripening stage in September and October, and were least acceptable in the ripe and early spent stages of development. Orange colour varied somewhat with mo of harvest and with sex, and free amino acid content and profiles varied considerably during the year. Glycine was the predominant free amino acid accounting for 18-60% of the total. Optimum eating quality was associated with lower levels of total free amino acids.

Résumé

Le rendement en laitance et en oeufs de l'ourson de mer vert (*Strongylocentrotus droebachiensis*) a varié de 30% à 22%, respectivement, à moins de 4% au cours d'une période de récolte d'un an. Les gonades furent les plus acceptables à la consommation dans la première phase de maturation en septembre et octobre, et furent les moins acceptables à la phase de maturité et au tout début du développement. La couleur orange a varié quelque peu avec le mois de la récolte et avec le sexe et la teneur en acides aminés libres. Les profils ont varié considérablement au cours de l'année. L'acide aminé libre dominant fut la glycine qui représenta 18-60% du total. La qualité comestible optimale fut reliée aux plus faibles teneurs en acides aminés libres.

Introduction

The green sea urchin (*Strongylocentrotus droebachiensis*) is the dominant macroscopic benthic animal along the coasts of Newfoundland. The urchin populations are concentrated in shallow water and in certain areas their density is as high as 350 urchins/m² (Himmelman, 1969). This organism is not harvested commercially for food at the present time; however, the roe and milt (male gonads) of urchins from other areas is highly valued for consumption as a raw or fermented product (Tanikawa, 1971). The present study was undertaken to evaluate the parameters relating to yield and eating quality of the green sea urchin in Newfoundland.

Materials and Methods

Urchins were harvested by divers at biweekly intervals from February 1980 to January 1981 in Portugal Cove,

Newfoundland. Specimens analyzed ranged from approximately 30-70 g and the median size of samples tested was approximately 50 g. Lots of twenty female and twenty male specimens were sacrificed and the roe or milt was manually separated from the organism. Gonad indices were determined for each mo. The gonad index is defined here as the gonad weight/urchin weight x 100. The fresh roe or milt was evaluated for taste preference by a sensory panel comprised of three to six individuals. One of the panelists had prior experience with the sensory evaluation of sea urchin gonads. Other panelists were briefed on the desirable taste attributes of raw sea urchin gonads. Desirable attributes were defined as a sweet and delicious taste. Undesirable sensory attributes were observed to be a bitter aftertaste and the presence of "egg yolk" and "seaweed" flavours. Panelists were asked

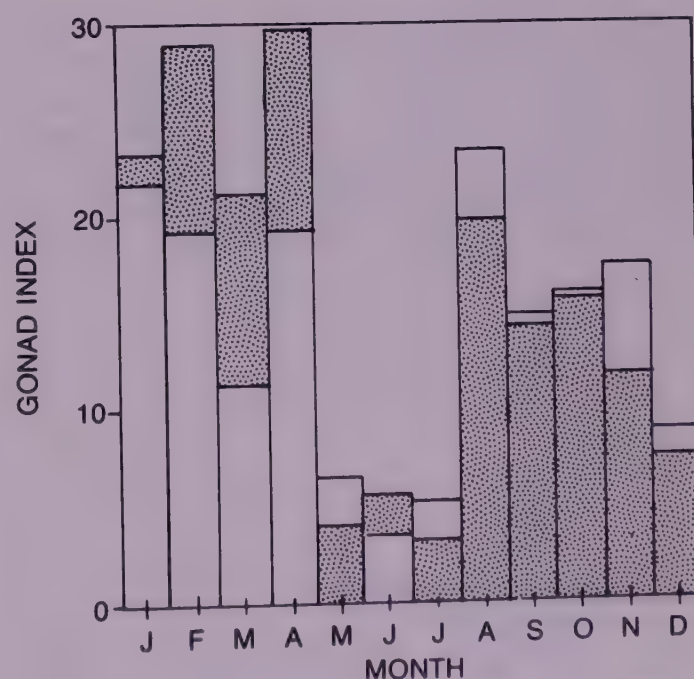


Fig. 1. Variation of gonad index for female and male sea urchin throughout the year.

Table 1. Sensory scores and amino acids at three stages of gonad development.

Development stage	Sensory score ¹		Total amino acids (% dwb)		Glycine (%)	
	Roe	Milt	Roe	Milt	Roe	Milt
Ripe (April)	1.8c	2.3b	10.9	10.6	58.8	59.6
Spent (July)	2.0a,c	2.8c	15.5	14.4	22.0	18.0
Early ripening (October)	4.0a	3.0b,c	6.5	8.5	41.0	52.1

¹Values with common letters are significantly different by T-test at indicated confidence level: a = 0.1%, b = 10%; c = not significantly different at 10% confidence level.

to rate the overall taste acceptability of the roe or milt as 4 (excellent), 3 (good), 2 (fair), or 1 (unacceptable). The orange colour of the gonads was evaluated by a reflectance spectroscopic method using a Hunter-Gardner colour difference meter, Model XL20. Orange colour was estimated by $\tan^{-1}a/b$ as suggested by Francis and Clydesdale (1975). Aqueous extracts of freeze-dried sea urchin gonads were analyzed for free amino acids using a Beckman Model 121 MB analyzer.

Results and Discussion

Gonad Index

The yields of milt ranged from approximately 30% in April, at the fully ripe stage, to less than 4% in July, following the spent stage of the gonads. The yields of roe ranged from approximately 22% in January, during the late ripening stage, to less than 4% in June, in the spent stage (Figure 1). The yield of roe tended to be greater than that of the milt in the late ripening and ripe stages from January through April. However, the yield of milt exceeded or equaled that of the roe in the early ripening stage of August through December. The yield of gonads exceeded 15% for 8 mo of the year.

Sensory Evaluation

The average scores for preference tests are summarized in Figure 2 and Table 1. Panelists preferred milt over roe, except for April (fully ripe stage), and for samples collected in October. The roe and milt were both rated least acceptable in April, and most acceptable in the late recovery and early ripening stages of September and October. The overall acceptance scores ranged from

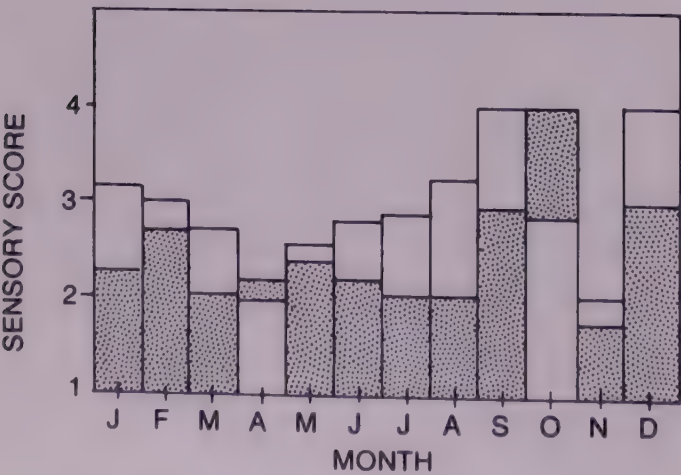


Fig. 2. Variation in eating quality of female and male gonads throughout the year.

good to excellent for 6 mo of the year and fair to good for the remaining 6 mo. The low ratings for roe and milt in November appear inconsistent with the overall trends and may relate to a sampling problem.

Colour

The orange colour of the gonads varied somewhat with time of harvest and sex (Figure 3). The roe had a more orange hue than the milt for samples collected in January through April, June and September through November; whereas the milt had a stronger colour in March, July, August and December. A value of $\tan^{-1}a/b$ of +45 indicates an orange hue; lower values are more yellow and higher values are more red.

Amino Acids

The total free amino acid content of milt varied in the ripe (10.6 g/100 g), spent (14.4/100 g) and early ripening stage (8.5/100 g) on a dry weight basis (dwb). The free amino acid content of the roe was similar at 10.9, 15.5 and 6.5 g/100 g dwb in the above respective developmental stages. Komata *et al.* (1962) reported that free amino acids are important to the taste of "uni," the raw or salted unripe gonads of sea urchin. Glycine was dominant in the related green sea urchin (*Strongylocentrotus pulcherrimus*), ranging from 35-41% of total free amino acids. Other amino acids considered important for taste were arginine, lysine, alanine, serine, glutamic and also methionine (0.6-0.9% of total amino acids), even though present in small quantities. The present study indicated a

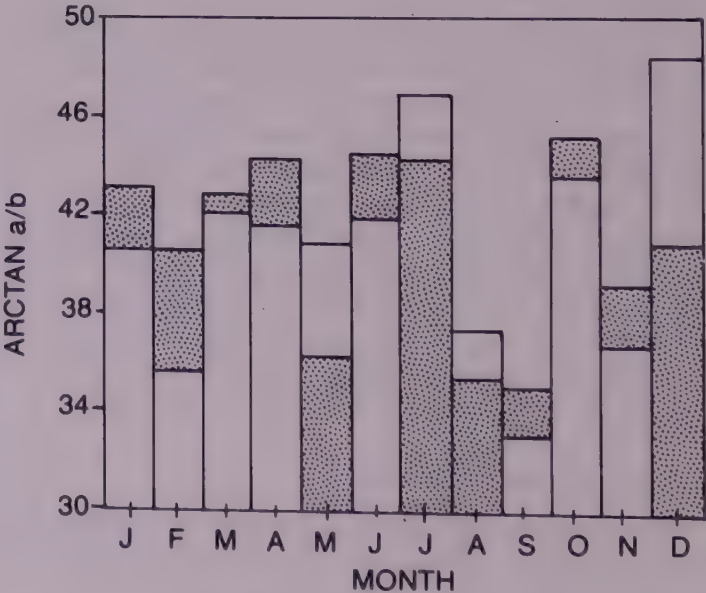


Fig. 3. Variation in arctan a/b of female and male gonads throughout the year.

Table 2. Amino acid profiles of sea urchin gonads.

Amino acid	Ripe (April)				Spent (July)				Early ripening (October)			
	Roe		Milt		Roe		Milt		Roe		Milt	
	mg (%)	% in total amino acids	mg (%)	% in total amino acids	mg (%)	% in total amino acids	mg (%)	% in total amino acids	mg (%)	% in total amino acids	mg (%)	% in total amino acids
Glycine	6401	58.8	6290	59.6	2795	18.0	3171	22.0	2681	41.0	4440	52.1
Alanine	945	8.7	1198	11.4	552	3.6	660	4.6	362	5.5	906	10.6
Glutamic	174	1.6	655	6.2	237	2.9	264	1.8	296	4.5	472	5.5
Glutamine	56	0.5	238	2.2	190	1.2	242	1.7				
Arginine	428	3.9	228	2.2	1392	9.0	1419	9.9	588	9.0	461	5.4
Lysine	332	3.0	199	1.9	1424	9.2	1322	9.2	454	6.9	386	4.5
Cystathionine	46	0.4	178	1.7	230	1.5	230	1.6	48	0.7	35	0.4
Serine	182	1.7	174	1.6	312	2.0	294	2.0	96	1.5	241	2.8
Hydroxyproline	88	0.8	162	1.6	41	0.3	63	0.4	34	0.5	96	1.1
Threonine	98	0.9	150	1.4	708	4.6	554	3.8	68	1.0	112	1.3
Aspartic	44	0.4	146	1.4	55	0.3	52	0.4	58	0.9	108	1.3
Taurine	128	1.2	142	1.3	50	0.3	93	0.6	78	1.2	168	2.0
Leucine	116	1.1	98	0.9	1426	9.2	1070	7.4	166	2.5	86	1.0
Tyrosine	96	0.9	88	0.8	1288	8.3	1104	7.7	206	3.2	73	0.8
Proline	Tr ¹	Tr	80	0.8	95	0.6	114	0.8	26	0.4	118	1.4
Valine	112	1.0	79	0.8	1143	7.3	932	6.6	150	2.3	70	0.8
Isoleucine	90	0.8	72	0.7	1062	6.8	828	5.8	106	1.6	66	6.8
Methionine	48	0.4	58	0.5	654	5.2	38	2.3	54	0.8	30	0.4
Phenylalanine	66	0.6	50	0.5	796	5.1	658	4.6	85	1.3	55	0.6
Asparagine	36	0.3	50	0.5	98	0.6	68	0.5	33	0.5	50	0.6
Histidine	33	0.3	36	0.3	403	2.6	328	2.3	68	1.0	44	0.5
Phosphoethanol-amine	32	0.3	34	0.3	Tr	Tr	Tr	Tr	Tr	Tr	20	0.2
Half cystine	66	0.6	21	0.2	62	0.4	26	0.2	46	0.7	2	0.0
Tryptophan	30	0.3	21	0.2	308	2.0	293	2.0	70	1.1	32	0.4
α-aminoadipic	Tr	Tr	18	0.2	34	0.2	42	0.3	10	0.2	9	0.1
Glycerophospho-ethanolamine	40	0.4	14	0.2	47	0.3	54	0.4	39	0.6	40	0.5
Cysteic	20	0.2	12	0.1	11	0.1	13	0.1	11	0.2	9	0.1
Sarcosine	1044	9.6	Tr	0.0	14	0.1	Tr	Tr	99	1.5	Tr	0.0

¹Trace.

similar profile of free amino acids in *S. droebachiensis* (Table 2). Glycine represented 18-60% of the total amino acids. There was no direct relationship between sensory scores and total free amino acid content or glycine content (Table 1) and it is likely that the taste of urchin gonads is influenced in a complex way by the balance of free amino acids as well as other substances such as nucleotides (Hirano *et al.*, 1978).

Conclusion

The present study indicates that the gonads of the green sea urchin are of sufficient yield and sensory quality to justify commercial exploitation. Our data indicate a harvest time of August through February would be most suitable (yield and sensory quality) for the Portugal Cove fauna sampled in this study. It is suggested that additional study is needed to confirm these observations and to evaluate the market potential of green sea urchin gonads.

Acknowledgement

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References

Francis, J. and Clydesdale, F.M. 1975. Food Colorimetry: Theory and Applications. AVI Publishing Company, Inc., Westport, CT. Page 208.

Himmelman, J.H. 1969. Some aspects of the ecology of *Strongylocentrotus droebachiensis* in Eastern Newfoundland. M.Sc. Thesis. Memorial University of Newfoundland, St. John's, NF. Page 159.

Hirano, T., Yamazawa, S. and Suyama, M. 1978. Chemical composition of gonad extracts of sea-urchin *Strongylocentrotus nudus*. Bull. Jpn. Soc. Sci. Fish. 44(9):1037.

Komata, Y., Kosugi, N. and Ito, T. 1962. Studies on the extractives of "Uni." 1. Free amino acid composition. Bull. Jpn. Soc. Sci. Fish. 28(6):623.

Tanikawa, E. 1971. Marine Products in Japan. Kossesha-Koseikaku Co., Tokyo, Japan. Page 507.

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RESEARCH NOTE

The Destruction of Aflatoxins in Peanuts by Microwave Roasting

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Abstract

The effectiveness of microwave roasting for reducing aflatoxin contamination in peanuts was investigated. Contaminated peanuts were treated in a specially constructed experimental microwave unit in 2 kg batches for various times at two different power levels. The results suggest that aflatoxin contamination can be consistently reduced by better than 95% by heating the nuts to a temperature of at least 150°C. The rate of heating appears to have very little or no effect since similar results were obtained for a 5 min treatment at a power level of 3.2 kW and a 16 min treatment at 1.6 kW. These treatments also resulted in a satisfactory degree of browning, while protein and fatty acid content were not measurably affected. The operating cost of a microwave processor is estimated to be 1.5¢/kg.

Résumé

On a évalué l'efficacité du grillage par micro-ondes comme moyen de réduire le niveau de contamination des arachides par l'aflatoxine. Des arachides contaminées ont été traitées dans un four expérimental de construction spéciale, par lots de 2 kg, pendant des périodes variables, à deux puissances différentes. Les résultats montrent qu'on peut systématiquement réduire le niveau de contamination par l'aflatoxine d'au moins 95%, en chauffant les arachides à une température d'au moins 150°C. La vitesse de chauffage ne semble avoir aucun effet important car on a obtenu des résultats semblables avec une puissance de 3,2 kW pendant 5 min et avec une puissance de 1,6 kW pendant 16 min. En outre, la méthode donne un grillage satisfaisant, sans modifier sensiblement la teneur en protéines et en acides gras. Le coût d'exploitation d'un tel four à micro-ondes a été évalué à 1,5¢/kg.

Introduction

The presence of aflatoxins, which are metabolites of the fungus *Aspergillus flavus*, in food is a great concern because aflatoxin B₁, in particular, has been shown to be an extremely potent liver carcinogen (Wogen, 1968). According to Scott (1969), peanuts are particularly liable to contamination and large quantities of peanut butter frequently have to be destroyed because of contamination not detected in the raw nuts. Conventional roasting, typically .5 h at 150°C, is reported to destroy only about

80% of the aflatoxin B₁ (Lee *et al.*, 1968). Initial experiments utilizing a domestic microwave oven indicated that heating with microwave energy could destroy aflatoxins more effectively than conventional heating, therefore it was decided to conduct a series of controlled experiments to verify the tentative findings.

Materials and Methods

Several bags of contaminated peanuts were obtained from the United States Department of Agriculture. Since aflatoxin contamination is usually caused by a relatively small number of highly contaminated kernels, aflatoxin levels in subsamples tend to be highly variable (Waltking *et al.*, 1968). Consequently, samples should be as large as possible. Taking into account the limited supply of nuts and the anticipated number of trials, a sample size of 4 kg was chosen. To ensure uniform heating of the nuts during the microwave treatment, a small experimental roaster was constructed as illustrated in Figure 1. The roaster comprises a cylinder made of perforated sheet metal, 1 foot in diameter and 2 feet in length. Microwave energy is introduced by means of a waveguide and rotating joint at one end of the cylinder, and an opening for charging and discharging the nuts is located at the opposite end. During the treatment the access hole is covered with a metal plate bolted in place and the drum is slowly

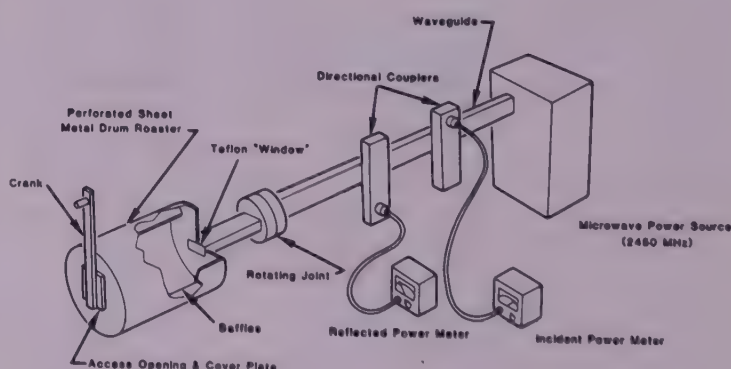


Fig. 1. Experimental microwave peanut roaster.

¹Formerly with McLarens Foods Ltd., Hamilton, Ontario L8H 7M3. Presently with Suncor Inc., P.O. Box 4001, Fort McMurray, Alberta T9H 3H3.

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rotated by means of a manual crank. Baffles were installed inside the drum to ensure adequate tumbling action. The microwave power source used was a Varian Industrial Power Pack operating at 2,450 MHz, with output power adjustable from 0-30 kW CW. Directional couplers and power meters were provided to monitor both incident and reflected power levels to determine the microwave power actually absorbed by the nuts.

Peanuts were processed in 2 kg batches, but in all cases two batches processed under identical conditions were combined to yield 4 kg of peanuts from each treatment. In the experiments, incident power levels of 2 kW and 4 kW were used to determine whether the rate of heating had any effect on the performance of the system or the quality of the final product. The reflected power varied with the rotation of the drum, but averaged about 400 W and 800 W, respectively, at the two power levels used, resulting in net absorbed power levels of 1.6 and 3.2 kW. The final temperature of the nuts was measured by inserting a thermocouple probe into the sample immediately following the microwave exposure.

Peanuts were analyzed for content of aflatoxins B₁, B₂, G₁ and G₂, protein, fatty acids and colour. Three tests were conducted on each sample. Aflatoxin analyses were performed using a thin layer chromatographic determination as specified in method FA-31, Food and Drug Laboratories, Ottawa, Ont., Canada (1971). The macroKjeldahl method was used to determine protein content, while a technique employing gas chromatography developed by Shehata *et al.* (1970) was used for the fatty acid determinations. Colour of the roasted nuts was judged by grinding the nuts to peanut butter and comparing the colour to that of standard colour plates available from the United States Department of Agriculture.

Results and Discussion

The effect of microwave roasting on the aflatoxin content of the samples is shown in Table 1. At a micro-

wave power level of 1.6 kW, a 16 min treatment resulted in residual aflatoxin levels of less than 5 ng/g, corresponding to a reduction of at least 95%, and yielded a product with good colour. When the power level was increased to 3.2 kW, a 5 min treatment reduced aflatoxin levels again by at least 95% to less than 5 ng/g and also roasted the nuts to an acceptable colour. It is of interest to note that in all cases where the final temperature was 150°C or higher, regardless of the rate of heating, aflatoxin levels were reduced to less than 5 ng/g, well below the maximum 15 ng/g allowed in peanut products.

The effectiveness of the microwave treatment in terms of "percentage reduction" is difficult to determine precisely since the method used for the aflatoxin analysis is not sensitive enough to yield accurate results below 5 ng/g. As well, the replicate analyses performed on the samples showed a typical variation of about $\pm 12\%$, probably due to variations within the samples.

Protein and fatty acid composition for the raw and treated samples is shown in Table 2. In general, for nuts roasted to an acceptable colour, the microwave treatment had no consistent effect either on protein content or fatty acid composition. Only when samples were overdone, such as in samples numbered 4, 13 and 14, was there a small decrease in protein content. Fatty acid composition appeared to be unaffected, even when the nuts were subjected to excessive microwave heating.

The cost of operating an industrial microwave system is approximately 11¢/kWh of microwave energy. This assumes the cost of electrical energy to be 3¢/kWh, an overall efficiency of 50% and maintenance costs (i.e., tube replacement) of 5¢/kWh. Based on our data, the cost of processing nuts in a microwave unit would be approximately 1.5¢/kg. Capital cost, of course, depends on the size of the installation. The cost of a 50 kW system, capable of processing 370 kg of nuts/h, would be of the order of \$100,000. A continuous microwave system would offer a number of additional benefits as outlined by Jolly (1972) whose impact ought to be con-

Table 1. The effect of microwave roasting on aflatoxin content of peanuts.

Sample	Microwave power (kW)	Exposure time (min)	Final temperature (°C)	Individual toxins (ng/g of peanuts)				Total aflatoxin (ng/g of peanuts) ¹	Aflatoxin reduction (%)	Comments
				B ₁	B ₂	G ₁	G ₂			
1	Control			41.7	8.0	5.7	0.7	55.7	0	Control - average 3 tests
2	1.6	10	120	12.0	1.8	—	1.0	14.8	73	Too light
3	1.6	15	137	15.0	0.6	1.0	0.6	17.2	69	Colour good
4	1.6	20		n.d. ²	n.d.	n.d.	n.d.	n.d.	100	Too dark
5	Control			68.8	9.3	16.7	1.5	96.3	0	Control - average 2 tests
6	1.6	16	163	<5	0	0	0	<5	>95	Colour good
7	1.6	18	168	<5	0	0	0	<5	>95	Too dark
8	3.2	4	126	17.5	3.1	17.5	6.2	44.3	54	Too light
9	3.2	4.5	140	44.6	5.7	21.5	4.5	76.3	20.8	Too light
10	3.2	5	150	<5	0	0	0	<5	>95	Colour good
11	3.2	5	151	<5	0	0	0	<5	>95	Colour good
12	3.2	5.5	160	<5	0	0	0	<5	>95	Slightly dark
13	3.2	6.5	176	<5	0	0	0	<5	>95	Too dark
14	3.2	7	185	n.d.	n.d.	n.d.	n.d.	n.d.	100	Too dark

¹ Average of three tests unless indicated otherwise. Typical variation $\sim \pm 12\%$.

² ≤ 1 ng/g of peanuts.

Table 2. The effect of microwave roasting on protein and fatty acid composition of peanuts.

Sample	Power level (kW)	Exposure time (min)	Dry matter (%)	Crude protein (% dwb ¹)	Fatty acid composition (Wt. %)						
					16:0	18:0	18:1	18:2	20:0	20:1	22:0
1	Control		94.8	31.9	10.3	3.0	48.6	29.4	2.3	2.5	4.0
2	1.6	10	96.3	32.9	10.8	3.0	49.2	28.5	1.9	2.5	4.4
3	1.6	15	96.8	33.1	10.6	2.9	50.3	29.0	1.7	2.2	3.8
4	1.6	20	98.1	31.2	10.4	2.8	48.9	30.3	1.8	2.0	3.8
5	Control		95.1	31.8	9.8	5.7	56.5	24.4	1.0	1.5	1.5
6	1.6	16	99.3	32.7	10.8	4.0	46.9	27.3	2.6	3.0	4.4
7	1.6	18	99.2	32.8	10.6	2.8	50.3	28.8	1.6	2.0	3.9
8	3.2	4	97.7	32.8	11.8	3.2	52.7	27.9	0.7	0.9	2.7
9	3.2	4.5									
10	3.2	5	96.2	32.8	11.5	3.1	51.9	29.1	Trace	1.0	3.9
11	3.2	5									
12	3.2	5.5									
13	3.2	6.5	98.4	31.9	11.8	2.7	48.7	29.5	1.8	2.4	3.5
14	3.2	7	98.3	31.6	12.3	3.8	50.8	29.5	0.6	1.7	3.3

¹Dry weight basis.

sidered when evaluating costs. Some of the benefits of a microwave system are a saving in floor space, reduced labour costs, convenience and ease of operation (no warmup), cleanliness and improved process control (instantaneous control of power level).

The authors feel that the results to date are sufficiently promising to justify construction of a small continuous pilot processor, possibly along the lines of equipment described by Faillon *et al.* (1977) for roasting cocoa beans. This would allow the use of much larger samples to verify the effectiveness of microwave roasting for the destruction of aflatoxins, and would also provide more accurate data regarding the economics of the proposed process.

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References

- Faillon, G., Couasnard, C. and Maloney, E.D. 1977. New uses of microwave power in the food industry. *J. Microwave Power* 12:79.
- Food and Drug Laboratories, Ottawa. 1971. The thin layer chromatographic determination of aflatoxins in peanuts. Acceptable Method FA-31.
- Jolly, J.A. 1972. Financial techniques for comparing the monetary gain of new manufacturing processes such as microwave heating. *J. Microwave Power* 7:6.
- Lee, L.S., Concullu, A.F. and Goldblatt, L.A. 1968. Appearance and aflatoxin content of raw and dry roasted peanut kernels. *Food Technol.* 22:1131.
- Scott, P.M. 1969. The analysis of foods for aflatoxins and other fungal toxins. *Can. Inst. Food Sci. Technol. J.* 2:173.
- Shehata, A.Y., deMan, J.M. and Alexander, J.C. 1970. A simple and rapid method for the preparation of methyl esters of fats in milligram amounts for gas chromatography. *Can. Inst. Food Sci. Technol. J.* 3:85.
- Waltking, A.E., Bleffert, G. and Kiernan, M. 1968. An improved rapid physicochemical assay method for aflatoxin in peanuts and peanut products. *J. Amer. Oil Chem. Soc.* 45:880.
- Wogan, G.M. 1968. Aflatoxin risks and control measure. *Fed. Proc.* 27:932.

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